The Natural History of Animals

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The Animal Life of the World in its various Aspects and Relations

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PREFACE

Signs are not wanting that at the present time a revival of interest in Zoology is taking place, and this book is an attempt to help on the movement by pointing out the various lines of study and explaining in simple language the views of modern specialists. Every effort has been made to treat the subject-matter in such a way as to interest the general reader, while at the same time the needs of junior students, amateur naturalists, and teachers of elementary Zoology (including "Nature Study") have been steadily borne in mind.

All the larger popular books on Zoology which have so far appeared in English take the various animal groups seriatim, a time-honoured plan which is in many ways valuable and useful, but which fails to bring out the complex interrelations that exist between the different groups, the interdependence of animals and plants, and the bearing upon life of chemical and physical conditions. A due appreciation of the great complexity of the struggle for existence, and a realization of our comparative ignorance regarding adaptation of structure to habit, should open innumerable fascinating lines of really scientific study to many amateurs who are at present mere collectors of insects, birds' eggs, or shells. It may, however, be noted that Half-Vols. I and II to some extent meet the needs of those who prefer the old plan, for they review in brief the entire animal kingdom, as a necessary preliminary to the study of the Food of Animals, Animal Defences, &c., which constitute the subject-matter of the remaining volumes. Even in the first two half-volumes, however, comparisons are constantly instituted between different animals and different groups, in illustration of general principles.

The Introduction fully explains the plan of the work, and the lines which have been adopted in writing it, and books to which the Author is specially indebted are mentioned in the text. It is both mentally and physically impossible for one zoologist to know at first hand more than a small part of his subject, and for this reason full quotations, in preference to mere paraphrases, have been taken from the writings of many distinguished specialists, the sources in such cases being always indicated.

Many of the coloured plates have been drawn expressly for this book by Mr. A. Fairfax Muckley and Mr. William Kühnert, and others are by Specht, the distinguished delineator of animal life. Some of the black-and-white plates, and many of the text illustrations are also new, and the remainder have been taken or re-drawn from acknowledged sources. Mr. R. A. L. Van Someren has been so good as to place at my disposal a number of his interesting photographs of birds and birds' nests, while Prof. D'Arcy W. Thompson and Mr. W. H. Reeves have obligingly supplied me with other original photographs.

Special acknowledgment is also due to the authors and publishers of *Das Tierreich*, *Die Schöpfung der Tierwelt*, *Das Leben des Meeres*, and *Tierische Schädlinge und Nützlinge* for their courteous permission to make use of other illustrations. My friend and colleague, Dr. H. J. Fleure, was so kind as to undertake the arduous task of editing the Index.

J. R. AINSWORTH DAVIS.

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CONTENTS

HALF-VOL. I.

INTRODUCTION

CHAPTER I

CLASSIFICATION—STRUCTURE OF MAN TAKEN AS A TYPE

CHAPTER II

ESSENTIAL CHARACTERS OF VERTEBRATE ANIMALS. STRUCTURE AND CLASSIFICATION OF MAMMALS (Mammalia)

CHAPTER III

STRUCTURE AND CLASSIFICATION OF BIRDS (AVES)

CHAPTER IV

STRUCTURE AND CLASSIFICATION OF REPTILES (REPTILIA)

CHAPTER V

STRUCTURE AND CLASSIFICATION OF AMPHIBIANS (AMPHIBIA)

LIST OF ILLUSTRATIONS

HALF-VOL. I

COLOURED PLATES

BLACK-AND-WHITE ILLUSTRATIONS

NATURAL HISTORY

INTRODUCTION

ON SCIENTIFIC METHOD

There are so many things to study in this world of ours, and outside it too, that it is no easy task to draw up a complete list of subjects. And supposing this done, it is a still harder task to determine the connection between the various subjects. This is not the place to attempt such a labour, and it will suffice for our present purpose to point out that in universities and other seats of learning it is customary to draw a distinction between "Arts" and "Science" courses, though the boundary line is indefinite. The Arts student is chiefly concerned with language, literature, mathematics, and philosophy; while the Science student, as such, is especially distinguished by the fact that he must work in the laboratory as well as in the lecture-room, at chemistry, physics, and biology, besides attending mathematical and, it may be, philosophical classes. It will thus be seen that mathematics and philosophy are considered common ground.

As this book deals with a branch of science, it may be well to enquire more particularly what "science" actually is. And here we have to distinguish between "pure" and "natural" science. "Pure" mathematics, the fringe of which is touched by all of us when we study arithmetic, algebra, and geometry, is an example of the former. It starts with certain self-evident truths, and makes deductions from these. The "natural" sciences, on the other hand, such as chemistry, physics, and biology, involve the study of facts by observation and experiment, these facts being afterwards used as a means

of determining the laws which regulate the universe. It is this special mode of procedure, the "*scientific method*", which distinguishes the natural sciences. The mode itself is known to everyone, though comparatively few could explain its exact nature. Huxley says (in his well-known address "On the Educational Value of the Natural History Sciences"): "Science is, I believe, nothing but *trained and organized common sense*, differing from the latter only as a veteran may differ from a raw recruit; and its methods differ from those of common sense only so far as the guardsman's cut and thrust differ from the manner in which a savage wields his club". The essence of the method consists in first ascertaining facts, resorting when necessary to experiment, then coming to some general conclusion based on the facts, and finally testing that conclusion by appeal to some case not previously investigated. Take, for example, the discovery of coal-seams by sinking a shaft through the chalk rocks at Dover. Prior to 1826 numerous observations had been made on the coal-bearing rocks in Somerset on the one hand and the north of France on the other hand, the conclusion being drawn that the two sets of rocks are practically identical. Twenty-nine years later, from these and many other additional facts regarding the distribution and arrangement of the coal-bearing rocks, Godwin Austen came to the conclusion that coal-fields exist far below the surface in the south-east of England. One such fact, the existence of coal below the surface-rocks of Oxfordshire, was determined by an experimental boring at Burford. Various considerations ultimately led to the selection of Dover as a suitable place for making a trial boring, which was begun in 1886 and completed in 1892. This boring proved the existence of a coal-field containing twelve seams of coal, the top of which is 1113 feet below high-water mark.[1]

Steps in above example of scientific method:—

1. The collection and arrangement of facts relating to the coal-fields of Somerset, north of France, and Belgium, some of the facts being determined by experiment.

2. Arrival at the following conclusion or generalization based on the said facts:—" Buried coal-fields exist in the area between

[1] The barest outline of the facts is here given. Details may be found in a pamphlet "On the Relation of Geology and Engineering," by Professor Boyd Dawkins, F.R.S.; being the "James Forrest" Lecture delivered at the Institution of Civil Engineers, Session 1897-98.—Published by the Institution, Great George Street, Westminster, London, S.W.

Somerset and north of France, the most likely locality being the neighbourhood of Dover".

3. Verification of the generalization. A shaft is sunk at Dover and a buried coal-field is actually discovered.

Among other striking examples of the scientific method may be mentioned the discovery of the Laws of Gravitation by Newton, and the discovery of the planet Neptune by Galle in the position where Adams and Leverrier independently prophesied a new planet would be found. It may be stated generally that when a theory or generalization enables us correctly to prophesy future events, that theory may be regarded as embodying one or more Laws of Nature. Thus, from calculations based on the theory of gravity, the position of the heavenly bodies at a given time can be predicted. Such calculations are to be found in the *Nautical Almanac*, published every three years, and these have always been found correct. Hence the Laws of Gravitation are regarded as Laws of Nature.

The scientific method is essentially experimental, and thus requires further illustration. Much can be done by observation only, but the progress of science would be exceedingly slow if it were not for *experiment*, *i.e.* the observation of facts under controlled conditions, enabling us to determine points which the mere watching of nature might never allow us to elucidate. Very good instances are found in the history of the "germ theory", which explains infectious diseases as only the action of microscopic organisms found within the body. Cattle, for example, are liable to be attacked by a most virulent complaint of the sort known as *anthrax* or *splenic fever*. It was noticed that the blood of animals which had died from this disease always swarmed with rod-shaped microscopic organisms, members of the large group of *bacteria* (microbes), the lowest subdivision of the vegetable kingdom. Mainly on the strength of this fact was founded the generalization—"Anthrax is due to rod-like bacteria in the blood". Then followed experiments designed to test the truth of this proposition. It was found that if healthy animals were inoculated with infected blood they quickly developed all the symptoms of anthrax, and died in the same manner and after the same time as in naturally occurring cases of the disease. A certain support

was thus given to the generalization, but the possibility that the rods might be the consequence and not the cause of anthrax was not excluded, and further experiments of more elaborate and painstaking nature became necessary. By well-known methods, "pure cultures" were made of the rod-shaped microbes, *i.e.* they were grown in an artificially-prepared medium, free from all other germs, in such a way that such other germs continued to be excluded. Healthy animals were then inoculated from these pure cultures, with the result that typical anthrax at once manifested itself. In this way the original generalization was experimentally verified. By similar methods of procedure many other diseases have been proved to be due to the noxious action of specific microbes. Other instances of the experimental method will be given in the course of this work.

In all such cases the value of the *imagination* can hardly be overestimated. To frame a reasonable generalization from a mere collection of facts requires a mental jump, so to speak, and the man of real genius in the scientific world—the "epoch-making" man—is he who can make such leaps in the dark with the best prospect of alighting on solid ground.

THE STUDY OF ANIMALS

Subject-matter of Biology.—All material objects are composed of what is known as "matter", about which all that can positively be stated is that it occupies space, takes up room, as we may say. Matter is liable to undergo change, and these changes are dealt with by chemistry and physics; by the former if they involve modification in composition; by the latter if they do not. One particular kind of matter is distinguished by the possession of life, which is recognized by its effects, though we are profoundly ignorant of its real nature. *Biology*, the science of life (Greek *bios*, life; *logos*, a discourse), deals with living matter, that is to say, with plants and animals, from all possible points of view. As organisms are constantly undergoing both chemical and physical changes, it is obvious that a knowledge of physics and chemistry is, to say the least, of immense value to the biologist. It has even been suggested that life will some day be explained by chemical and physical laws; but, even if

such mechanical explanation be possible, that day is far distant, for at present our knowledge of the composition of living substance is exceedingly crude and imperfect.

Subdivisions of Biology.—So vast a subject as that dealing with life obviously needs subdivision for purposes of convenience, and it is customary to recognize two main branches, *Botany* and *Zoology*, dealing with plants and animals respectively (Greek *botanē*, a plant; *zōŏn*, an animal). This does not mean, however, that there is any sharp boundary between the animal and plant worlds. No doubt it is easy to tell the difference between a higher plant and a higher animal, though it might not be so simple to point out in exactly what the difference consists; but when we come to microscopic organisms, difficulties soon arise, and the usual tests break down. Well-defined lines of division but rarely occur in the organic world.

In this book we shall confine ourself in the main to *Zoology*, or *Natural History* as it is often called, but reference to the vegetable kingdom will have to be made in many connections, owing to the obvious fact that there is a very intimate relation between plants and animals.

Ways of Studying Zoology.—Animals, of course, can be studied from various stand-points, some of which will here be mentioned, as they form a basis for the splitting up of the subject. The accumulated observations of thousands of observers constitute such a mass of knowledge (one, too, that is ever growing), that it is a hopeless task for any individual to acquaint himself with what is already known, and even the professional zoologist can do no more than acquire a general knowledge of his subject, with special knowledge of some limited branch. And when we reflect that, after all, the known is very small, while the unknown is stupendously large, in amount, the present tendency to specialization becomes fully intelligible. It is nevertheless quite easy for anyone of average intelligence to acquire sound general ideas regarding the various possible modes of attacking the subject.

1. *The Stand-point of the Naturalist.*—Zoology to the naturalist is essentially an open-air study. He delights in watching living animals with the view of finding out all he can about their habits, naturally learning at the same time a great deal about their external features, and also finding it necessary to know something

about classification. Nearly every country child is a naturalist in this sense, not to mention many older persons, though for some decades there has been an unfortunate tendency to ignore habit and pay overmuch attention to what we may call laboratory zoology. The most admirable type of English naturalist is undoubtedly Gilbert White, author of the well-known book, *The Natural History of Selborne*, in which he records observations made by him during his residence there. Selborne was his native place. Born in 1720, he later on filled a curacy in the neighbouring parish of Faringdon (1755–84), ending his life as curate of Selborne (1784–93). The late Richard Jefferies, himself an ardent naturalist, speaks of White in a preface written to the Camelot edition of the *Natural History*. After quoting an observation as to the way the garden warbler sips honey from the Crown Imperial, Jefferies remarks:—"Here we . . . see how different minds may trace out the bearing of the same fact. The old naturalist at Selborne simply records it in language which could not be better chosen, highly delighted evidently, and taking a deep interest in it for its own sake. In the same manner, anyone who has a taste for out-of-door observations may study natural history without any previous scientific learning. . . . Part of his (White's) success was owing to his coming to the field with a mind unoccupied. He was not full of evolution when he walked out, or devolution, or degeneration. He did not look for microbes everywhere. His mind was free and his eye open. To many it would do much good to read this work, if only with the object of getting rid of some of the spiders' webs that have been so industriously spun over the eyesight of those who would like to think for themselves." Fortunately a reaction has been setting in of late in favour of natural history, and we are beginning to realize that far less is known about the habits than about the structure of animals.

Among charming books of the kind the following may well be mentioned:—

Bates—*Naturalist on the Amazons.*
Belt—*Naturalist in Nicaragua.*
Brehm—*From North Pole to Equator.*
Buckland—*Logbook of a Fisherman and Naturalist*, and *Curiosities of Natural History.*
Darwin—*A Naturalist's Voyage.*
Forbes—*A Naturalist's Wanderings in the Eastern Archipelago.*
Fowler—*Tales of the Birds*, and *A Year with the Birds.*

Gosse—*A Year at the Shore*, and other works.
Hickson—*A Naturalist in North Celebes.*
Hudson—*The Naturalist in La Plata.*
Jefferies—*Red Deer*, and other works.
Lloyd Morgan—*Animal Sketches.*
Moseley—*Naturalist on the "Challenger"*.
Semon—*In the Australian Bush.*
Fred Smith—*Boyhood of a Naturalist.* A little book which breathes the spirit of Gilbert White in every page.
Wyville Thomson—*The Depths of the Sea*, and *Voyage of the "Challenger"*.
Thoreau—*Walden.*
Wallace—*Malay Archipelago*, and *Tropical Nature.*
Waterton—*A Naturalist's Wanderings in South America.*

The camera has lately with great success been pressed by the brothers C. and R. Kearton into the service of outdoor zoology, but this has not been done without untiring patience and the expenditure of a very large amount of time. Their books, *With Nature and a Camera*, *British Birds' Nests*, and *Wild Life at Home*, are ideally illustrated.

2. *The Stand-point of Classification.*—Such an enormous number of animals exist (considerably more than a million kinds being now known to science) that as a matter of convenience it is found necessary to classify them, that is, to arrange them into groups according to their likenesses and differences. Animals have always played such an important part in the lives of human beings, as sources of food, clothing, ornament, &c., and as objects of interest, that even the most primitive languages contain words for different kinds of animal. The names of those animals which have been longest domesticated, such as ox and sheep, are thus found to be of extremely ancient origin, and the same is true in the case of certain widely distributed and conspicuous wild forms, such as mouse, midge, beaver, and eel. But in addition to this we have class-names, such as bird, fish, snake, &c., which constitute the unconscious beginning of a rough classification, as they embody the fact that many kinds of animal collectively form a larger group, *e.g.* that of birds. But besides this we learn from the literature of many cultured peoples that even in early times deliberate attempts at classification were made. An example of this may be found in Genesis, i. 26, where we read, ". . . let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, . . . and over every creeping thing

that creepeth upon the earth". Solomon is represented (1 Kings iv. 33) as using the same fourfold division, except that the word "beast" is used instead of "cattle". The creatures included under the former term are evidently those which are popularly called "quadrupeds" at the present day, while scientifically they are known as "mammals". The lower terrestrial forms of life are embraced by the comprehensive term "creeping things". The word "insect" was used in English till comparatively recently much in the same way. This crude classification is clearly based on the nature of the media in which the various animals live, *i.e.* it is a division into animals living respectively on the land, in the water, and in the air, land animals being further subdivided into higher and lower forms. Such a grouping is of necessity very superficial, for habitat is a very misleading guide to affinity or likeness. Whales, porpoises, and seals are as much "beasts" as cows and sheep, though to this day we speak of whale and seal "fisheries". And further, such a group as "creeping things" or "insects" (in the old sense) contains such a miscellaneous assortment of creatures that it may be looked upon as a mere receptacle for forms finding no place in the other three subdivisions.

The first man to place zoology on a scientific basis was the Greek philosopher Aristotle (384–322 B.C.), "perhaps the greatest and most truly scientific man in the highest sense of the word that the world has ever known" (Milnes Marshall), who, though the study of animals was not the one to which most of his time was devoted, has nevertheless been styled the "Father of Natural History". Aristotle had a very considerable knowledge of the habits and structure of the animals known to him, about 500 in number; he was impressed by the fact that the animal kingdom exhibits a transition from lower to higher, and devised a scientific system of classification based on structure. His great merit here lies in the fact that he divided the animal kingdom into two groups,—(A) Animals with red blood and a backbone, and (B) Animals without red blood and no backbone, a division which corresponds precisely with the modern one into Vertebrata (Backboned animals) and Invertebrata (Backboneless animals), though we now know that the distinction as to blood is not quite so absolute as Aristotle supposed. He further recognized five classes among the backboned animals (viviparous

quadrupeds producing living young, egg-laying or oviparous quadrupeds, birds, fishes, and whales), and four among the backboneless (molluscs, scaly animals, animals with soft scales, and insects).

Unfortunately, after the time of Aristotle zoology progressed in a backward direction, and during the Middle Ages all sorts of absurd ideas gathered around it. A fresh start was made by Wotton (1492–1555), a native of Oxford who afterwards became a London physician. He went back to the classification of Aristotle, and from his own observations enlarged upon it. Further work in the same direction was afterwards done by the Swiss professor, Gesner (1516–65), and by the Englishman, John Ray (1628–1705), work which led up to the better known and more extensive labours of Karl von Linné, usually known by the name of Linnæus (1707–78). As professor of Natural History in the Swedish university of Upsala, he wrote his *System of Nature*, which must ever remain a classical work, and in which are laid down the foundations of our modern classification. Comparing the plant and animal worlds to armies, he instituted a series of subdivisions named, beginning with the largest, class, order, genus, and species, metaphorically equivalent to the legions, cohorts, maniples, and contubernia of a Roman host. His animal classes were six in number. Linnæus also introduced the system of giving each kind of animal a double name, the first being that of the genus, the second that of the species. We find living in Britain, for example, three kinds or species of hare-like animals, all belonging to the genus *Lepus*, and called in popular language rabbit, hare, and Alpine or Irish hare. The double scientific names of these are respectively, *Lepus cuniculus*, *Lepus timidus*, and *Lepus variabilis*. The utility of such names is obvious, for if in recording observations on, say, the rabbit, we speak of it as *Lepus cuniculus*, a zoologist of any nationality whatsoever will know to what animal we are referring, while merely to employ the popular name might lead to great confusion. It will be noticed that the first or generic name is comparable to a surname, while the second or specific name may similarly be compared to a Christian name. The generic name is placed first merely as a matter of convenience, just as in an official list of human beings, such as a list of voters, it is found more convenient to give first place to the surname. By universal consent, scientific names are almost entirely taken from

the dead languages, Latin and Greek, as these are studied by all civilized nations. Unfortunately many such names are clumsy, and some are barbarous mixtures of Latin and Greek; but in spite of this the system is a good one.

The classification of Linnæus, like that of Aristotle, is a "classification by definition". As a result of observation, certain groups are *defined*, *i.e.* their essential characters are given, and newly-discovered animals are placed in this or that group according as they are found to possess or lack certain features. Such a classification assumes the existence of sharp boundary lines in nature, and is really based on the idea that the different kinds or species of animal were created separately and independently. The Linnean Class of *Mammals*, for instance, is defined as being a group of viviparous animals, possessing a four-chambered heart and hot red blood. Any newly-found kind of animal possessing these features would be considered a mammal. In framing such a classification comparatively few prominent features are selected, and more attention is paid to the boundary lines than to the resemblances between the animals constituting a group. This particular method of subdivision is by no means confined to natural history; an example from another province is afforded by the classification of Britons according to income for income-tax purposes. Those individuals falling well within a subdivision are of no special interest, but those only just coming up to the amount of a particular class are objects of commiseration to themselves as paying a particular percentage with the least reason, while on the other hand those who only just escape falling within a more highly-taxed section have a special interest for the assessors.

After the time of Linnæus the rapid progress of more accurate observation, now aided by fairly good microscopes, gradually led to the conviction that classification by definition is far from satisfactory, and to a reaction against the current idea that the different groups of the animal kingdom form a linear series, a gradual ascent from low to high in, so to speak, a straight line. The next important scheme of classification, which we owe to the great French anatomist Cuvier (1769–1832), is one by "type". This system lays stress upon the resemblances between the members of a group rather than on the boundary lines between different groups, or, in other words, "The class is steadily fixed, though not precisely limited; it is given, though not circumscribed; it is

determined, not by a boundary line without, but by a central point within; not by what it strictly excludes, but by what it eminently includes; by an example, not by a precept; in short, instead of a definition we have a type for our director" (Whewell). Cuvier was the first to recognize the fact that the different groups of animals are related to one another like the branches of a tree, and not like successive portions of a straight line. He recognized four great branches—Vertebrates, Molluscs, Articulates, and Radiates, each distinguished by its special type of structure.

Since Cuvier's time it has come to be more and more recognized that in a "natural" classification, *i.e.* one having regard to as many distinctive features as possible, in contradistinction to an "artificial" system which regards only one or a few arbitrarily chosen characters, the groups of animals must be represented diagrammatically by a tree, in which the large branches represent the large groups, their subdivisions the smaller groups, and the leaves individuals. This conclusion has been greatly supported and extended this century by the study of extinct animals, placed on a scientific basis by Cuvier himself; and by the teachings of development or embryology, a zoological branch of which the foundations were firmly laid by von Baer (1792–1876).

The real meaning of this tree-like arrangement of organisms was at first a mystery, but, thanks more particularly to Charles Darwin and his contemporary Alfred Russell Wallace, who is fortunately yet among us, we now understand it to be an expression of an actual blood-relationship—to be, in fact, a veritable genealogical tree, the outcome of a process of evolution. And hence classification at the present time is a "classification by pedigree", and is perfect, in so far as we are successful in arranging animals according to their actual affinities.

3. *Zoology as regarded by the Morphologist or Student of Animal Form.*—One of the main subdivisions of modern zoology is the branch dealing with the shape or form of animals, using these words in their broadest sense. This part of the subject is *Animal Morphology* (Gk. *morphe*, form; *logos*, a discourse); and it deals not only with the external characters, the outward form, but also with the structure or inward form, as revealed by dissection and by the use of the microscope. The external characters of animals were naturally those first noticed; then came the study

of their anatomy, to which Cuvier gave an immense impetus; and lastly, the investigation of minute structure or histology (Gk. *histŏs*, a texture), which, though the compound microscope was invented near the end of the sixteenth century, practically began as a serious study with Malpighi and others nearly a hundred years later, and has rapidly advanced up to the present time, every successive improvement of the microscope leading to the acquisition of more extended and more accurate knowledge. The microscope, too, besides vastly increasing our knowledge regarding the structure of well-known animals, has thrown open to investigation a once unsuspected world of minute forms, just as the telescope has extended our field of observation in the other direction.

Morphology, however, is not content with merely cataloguing facts regarding the structure of different sorts of animals. It compares and classifies these facts, and endeavours, as far as may be, to explain them in the light of the evolution theory. Innumerable problems are met with, many being of the most fascinating description, and the solution of these constantly engages the attention of numerous expert workers. Some of these questions are naturally very abstruse, but many of them, when properly presented, are certain to excite the interest and arrest the attention of almost any intelligent person. As a good example of such a problem and its solution we may take the nature and origin of teeth.

Teeth, as seen, for example, in a dog or cat, are hard bodies having a certain complex structure, and developed by the lining of the mouth-cavity. The question may be asked—"How have teeth been evolved, and are any other parts of the animal body comparable with them?" No answer can be given to this unless the comparative method be adopted (a method we owe to the illustrious German biologist, Johannes Müller, and which is of supreme importance in zoological matters) and a general survey taken of the backboned animals generally. Mammals, birds, and amphibians do not afford a solution of the problem; but on coming to fishes we find that many of them possess numerous hard defensive bodies in the skin known as "placoid scales", which vary greatly in shape in different cases. Now these scales greatly resemble teeth in structure, and if in a dogfish we closely examine the neighbourhood of the mouth, it will be found that

the placoid scales gradually become more and more tooth-like as regards shape, all the intermediate stages being found. To this it may be added that the mouth-cavity develops as a pit or depression in the surface of the body, so that its lining is really specialized skin, and might be expected to produce similar structures to those characteristic of skin. Piecing together these various facts we arrive at the conclusion—"Teeth have resulted from the modification of scales belonging to the mouth-cavity", a conclusion which is rendered still more probable when we find that teeth are by no means limited to the edges of the jaws, but may also be found (in some fishes, reptiles, &c.) on the roof and other parts of the mouth-cavity. That teeth should persist in animals like mammals, which have long since lost the original scaly covering of remote ancestral forms, is explained by the principle of "change of function", often exemplified by organs which are out of work from having lost their original job. This is a case of primarily defensive structures which have been pressed into the service of the digestive system, though they may also, in certain instances, again be modified for defence and offence on new lines.

4. *The Physiologist's Stand-point.*—Students of physiology are, like naturalists, interested in the life-manifestations of animals, but their enquiries are more subtle, and aim at determining the uses or functions of the various parts revealed by anatomy and histology. To determine the nature of life is the final aim of the physiologist. The several departments of zoology are so intimately related that they are briefly described here under separate headings merely as a matter of convenience. This is particularly true of physiology and morphology, which are so closely interwined that it is impossible to separate them. The study of form would be extremely dull and largely profitless without some knowledge of function, and the study of function presupposes a preliminary knowledge of form. For example, a far more vivid interest is imparted to a description of the structure of the eye if the uses of its various parts are kept in view, while any explanation of vision would obviously be impossible were the related anatomical facts ignored. A very good example is afforded by the tooth problem, dealt with in the last section, where questions both of morphology and physiology are involved.

5. *The Embryologist's Stand-point.*—The study of form and

function when applied to animals before they reach the adult condition is known as Embryology or Development. From very early times it attracted a considerable amount of attention, but was first placed on a really scientific footing by von Baer (1792–1876), and as the result of the labours of many specialists, notably Francis Maitland Balfour (1851–82), formerly Professor of Animal Morphology in the University of Cambridge, and the Russian zoologist Kowalewsky, is now an important, perhaps even an overestimated, branch of the subject. As in so many other cases, the interest of the facts has been enormously increased as a result of the influence of the theory of evolution. Consisting as the subject-matter does of the life-histories of animals, it has always formed part of the work of the field naturalist, who has delighted in the mysterious growth of frog from tadpole, or the passage of caterpillar into chrysalis, and that again into the butterfly. Such interest had quite a new turn imparted to it when the evolutionist formulated the "Law of Recapitulation", according to which, in the words of Milnes Marshall, "every animal in its own development repeats its history, climbs up its own genealogical tree". Thus interpreted, the fish-like tadpole points to the descent of frogs from ancestors which in many respects possessed those characters which we now associate with fishes. There has been, however, a tendency to exaggerate the importance of this law.

6. *The Stand-point of Distribution.*—Under this heading two things call for consideration—(*a*) Distribution in Space and (*b*) Distribution in Time.

(*a*) *Distribution in Space.*—Everyone knows that different countries are inhabited by different sorts of animals, *e.g.* that kangaroos are to be found in Australia, ostriches in Africa, and sloths in South America. Until the rise of the evolution theory no explanation was given of such facts, except that animals have been created separately where we now find them. This was the doctrine of "special creation", and if we adopt it, the study of distribution can be little more than a recording of facts. Admitting however, the truth of the evolution theory, it becomes possible to give a reasonable explanation of many curious and at first sight anomalous instances of the sort. We have, for example, the well-known case of the tapir, an animal somewhat resembling the pig in appearance but possessing a short proboscis. These creatures are only found in South America and the Malay region. We know,

however, from geological evidence, that animals of the kind formerly existed in North America, Europe, and Asia, and their present occurrence in two widely isolated areas is thus explained, extinction (dying out) having taken place in the intervening tracts owing to the competition of other forms of life.

(*b*) *Distribution in Time.*—As will be fully explained in the sequel the study of geology enables us to some extent to carry back the study of animal life to periods immensely remote from the present, and to construct a history of animals in chronological order. As, from an evolutionary stand-point, we might expect, there has been on the whole a progress from low to high, and it is even possible to work out with some approach to accuracy the pedigrees of certain existing groups. We learn that some forms, including Man himself, are of comparatively recent origin, while, on the other hand, there are many groups of animals which have no living representatives. Much light is also thrown, as indicated above in the case of the tapirs, upon problems of distribution in space.

7. *The Utilitarian Stand-point.*—We may include under this heading not only economic zoology, dealing with the animal kingdom as a source of food, clothing, ornament, &c., but also facts regarding animals as they appeal to the sportsman, the keeper of pets, and the lover of the beautiful.

Economic zoology, though largely statistical, also involves issues of more general interest, such as the improvement of farm stock, fish-hatching, oyster culture, and bee-keeping. Facts observed from a purely practical stand-point in these and other departments of applied zoology have often proved invaluable to theorists, as appears abundantly in the pages of Darwin's great work, *Plants and Animals under Domestication*; while, on the other hand, researches conducted by theorists have repeatedly borne practical fruit.

As regards animals in a sporting connection, it commonly happens that sportsman and naturalist are combined in the same individual, and our knowledge of the habits of many animals is largely derived from this source. Such books as Sir Samuel Baker's *Wild Beasts and their Ways*, Shield's *The Big Game of North America*, and Chapman's *Wild Norway*, *Wild Spain*, and *Bird-life of the Borders*, among innumerable others, illustrate this point.

Animal Æsthetics, dealing with animals as objects of beauty,

is a branch of zoology which can scarcely be said to be organized, but it is a commonplace to say that animal form and colour have always proved more or less attractive to painters, sculptors, and human beings in general. The uses of animals, parts of animals, or animal products for ornamental purposes fall to be treated of by economic zoology. The old idea was that the beautiful or striking forms and colours of plants and animals were intended solely for the gratification of human tastes. Modern theory interprets them as playing some part with reference to the organisms themselves. Predatory animals are often coloured so as to render them inconspicuous to their prey, while, on the other hand, many creatures are thus protected to some extent from their enemies. Conspicuous colours and markings, such as those of the wasp, may be of "warning" nature, acting as danger-signals, while some of the most beautiful tintings are plausibly explained as "courtship colours", *e.g.* the brilliant scarlet hues assumed by the male stickleback during the nesting season.

8. *The Philosophic Stand-point.*—The groundwork of zoology undoubtedly depends on observation of the various classes of facts enumerated under the preceding headings, but this is not the highest development of the subject. Here the palm must be given to zoology considered as a branch of philosophy, aiming at the explanation of the facts relating to animal form, function, and distribution by means of theories founded on such facts. Thus we see an otherwise chaotic mass of material falling under general laws, and assuming orderly proportions, as in the sister sciences of astronomy, chemistry, physics, and geology. All intelligent workers in the zoological field, whatever may be their special branch—form, function, development, classification, or what not,—adopt the philosophic stand-point more or less, for without a reasonable admixture of theory the subject-matter of zoology is but as bread without leaven, or meat without salt.

Although speculation, often crude, it is true, has always been more or less associated with the study of living beings, its influence as a revolutionary and stimulating agent undoubtedly dates from 1859, the year in which Darwin and Wallace formulated their theory of evolution. And it is the especial glory of zoology that the theory then propounded has had the most wide-reaching influence, not upon biology alone, but upon every branch of learning. For biology connects on the one hand with subjects

such as chemistry, physics, and geology, and on the other with the study of mankind and the works of man. From morphology and physiology we pass, though not without huge gaps in knowledge, to the study of mind (psychology), sociology, political economy, law, ethics, and history, while even linguistic students are nowadays confronted with problems best explained on an evolutionary basis.

THE PLAN OF PRESENT WORK

Most popular modern books on zoology written in English deal with the various groups seriatim, beginning with the highest forms and ending with the less familiar creatures, our knowledge of which is mainly due to the microscope. Of such books Cassell's *Popular Natural History* and Lydekker's *Royal Natural History* may be mentioned as admirable types.

This plan is not here followed, but an attempt is made to treat the subject in a comparative manner, taking function as the basis, and illustrating the various points as they occur by examples taken from all or many of the animal groups. It is believed that this plan is better adapted than the other for bringing into relief the most interesting facts and theories of modern zoology. Such a mode of treatment was once much in vogue, both in lecture courses and in books like the late Dr. Carpenter's *Animal Physiology*.

A sketch of *Classification* will first be given, so as to familiarize the reader with the chief groups of animals and the range in form presented by the animal kingdom, especially as regards external characters. Special attention will be given to familiar forms, particularly such as are native, and those which may be commonly seen in zoological gardens. This will be followed by a section on the *Food and Feeding of Animals*, with special reference to interesting modifications and adaptations resulting from the various ways in which animals get their livelihood, if one may use the expression. *Animal Defences* will next be treated, and this section is closely connected with the preceding, as means of defence are mainly necessary to protect animals from the attempts of other animals to eat them. *Breathing and Movement*, as two primary functions, will form the subject of the next two sections, under which will be fully treated adaptations for

breathing in air and in water, and modes of movement above-ground, underground, in water, and in air.

The subject of *Development* will next be dealt with, and typical life-histories will be given, after which such subjects as *Care of Eggs and Young* and *Animal Homes and Dwellings* will receive attention.

The lower functions of animals having been dealt with in the earlier sections of the book, the higher functions will next be considered, and some of the more important details regarding the structure and function of *Nervous System* and *Sense Organs* will be presented. This will be followed by a section on *Instinct* and *Intelligence*, activities involving the operation of the organs described in the preceding section. Such matters as the migration of mammals and birds, the habits of social insects (ants, bees, wasps, &c.), and the "homing instinct" of certain forms, will here receive treatment.

In the remaining part of the book considerable space will be devoted to the wide and interesting questions connected with the *Association of Organisms*. The first thing here to be dealt with will be the various kinds of association obtaining between plants and animals, such as the relation of insects to flowers, ants to various plants, insectivorous plants, and galls produced by insects. Next will follow an account of the chief kinds of association between animals of the same species, including chapters on Mating and Courtship, and on Animal Communities, in so far as the last subject was not treated of in relation to instinct. Different kinds of association between organisms of different species will be the last heading under this section, and will include all the various sorts of relation known to biologists, among these being *Commensalism*, where messmates are associated; *Mutualism*, where there is an intimate beneficial union; and *Parasitism*, in which unwelcome guests prey upon a "host".

The concluding sections of the book will be devoted to Utilitarian Zoology, Distribution in Space and Time, and Philosophical Zoology.

Under *Utilitarian Zoology* we shall have occasion to deal with animals as the foes and friends of man, and this will naturally involve some description of the chief ways of coping with foes, *e.g.* agricultural pests, and some of the methods, *e.g.* pisciculture, by which the usefulness of animals is enhanced. Some space

will also be devoted to domestic animals, animal pets, sporting zoology, and animal æsthetics.

Distribution in Space will be illustrated by typical cases, involving a brief exposition of leading principles. A short account of life as modified by various surroundings will follow, and such subjects as deep-sea, fresh-water, and underground faunas will here receive treatment.

Distribution in Time will involve a sketch of the ancient life-history of the earth, under which the most interesting extinct forms will, of course, be described.

The section on *Philosophical Zoology* will of necessity be chiefly occupied by some account of the Theory of Evolution, and of related matters, such as the question of Heredity.

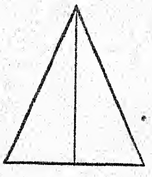
CHAPTER I

CLASSIFICATION—STRUCTURE OF MAN TAKEN AS A TYPE

GENERAL CONSIDERATIONS

In considering any scheme of classification, and in subsequently dealing with the various functions of animals, reference will constantly have to be made to external characters and to various sets of organs and their mode of action. It would therefore appear desirable, in order to clear the ground, to give some account of certain points of fundamental importance, and this can perhaps best be done by fixing our attention at start upon some familiar organism. It is undoubtedly the best plan to begin with the known, and from this to proceed to matters regarding which the majority of readers are more or less ignorant, though throughout this book no technical knowledge will be assumed. And for various reasons, such, *e.g.*, as that a very large number of persons have some elementary acquaintance with Human Anatomy and Physiology, it is deemed advisable to begin this chapter by a brief account of the structure and life-functions of man himself.

SYMMETRY.—The body of a human being, and the same is true for the common domestic animals, is built with a certain sort of regularity to which the name of two-sided or *bilateral symmetry* is applied. And to fully appreciate what is meant by this we must suppose the body to be placed with its front surface downwards, as is permanently the case in a dog, rabbit, or frog. This is clearly necessary, for if we are to compare man with the lower animals the same relative positions must be assumed for purposes of description.



Bilateral symmetry means, then, that the body can be divided into two corresponding halves in one way and one way only. Simple examples of this kind of regularity are afforded by an isosceles (or equal-sided) triangle, many leaves, and most of the

so-called irregular flowers. The two halves, conveniently termed right and left, are not exact counterparts, but are what has been termed mirror-images. That is to say, if one half be placed with its cut surface against a mirror its reflection will correspond to the missing half. But bilateral symmetry in an animal involves more than a distinction between right and left, it means also, or the terms right and left could not be properly used, a distinction between front (anterior) and back (posterior) ends. Not only so, but we further perceive that an upper (dorsal) surface can be recognized as distinct from an under (ventral) surface. These points come out somewhat more clearly in lower animals

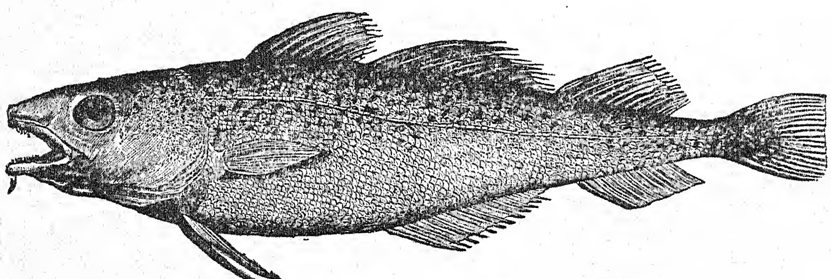


Fig. 1.—Cod-fish (*Gadus morrhua*)
The pelvic fins are seen under the throat and a pectoral fin on side of body above them.

than in man. Take, for instance, a fish, say a cod (fig. 1). The anterior end is clearly the head-end, the end which under ordinary circumstances goes first, and which, therefore, naturally bears the mouth, and is provided with the most important sense organs, such as those of smell, sight, and hearing—here most conveniently situated, as organs by which the presence of food, or it may be of enemies, is mainly perceived. The posterior or tail end bears in this animal a powerful propeller in the form of a fin. We also see marked differences as regards the dorsal and ventral surfaces, having an obvious relation to the needs of the animal. These differences are partly of form and partly of colour. Nothing need here be said on the former head, but as to the latter we note that the dorsal surface is dark while the ventral is pale, an arrangement which, as will be fully explained elsewhere, makes the animal match its surroundings much better than would otherwise be the case. Bilateral symmetry, therefore, is essentially a distinction between right and left, anterior and posterior, dorsal and ventral. It may be taken as an

expression of the fact that the external influences which act upon the body are different in different directions, and we must seek in this fact an explanation of the origin of such symmetry. Were external influences the same in all directions we might expect the body to be spherical, but as this obviously can rarely or never be the case, we are prepared for the fact that absolutely spherical animals scarcely exist. In certain fixed forms, however, as coral polypes (fig. 2) and the like, we do get radial or star-like symmetry, where there is a distinction between upper and lower, but none between right and left, or posterior and anterior. In such a case the part of the animal facing upwards is exposed to the light, while the part facing downwards is shaded. All parts of the margin, however, are, on the whole, liable to be acted on in much the same kind of way—by light and other external influences.

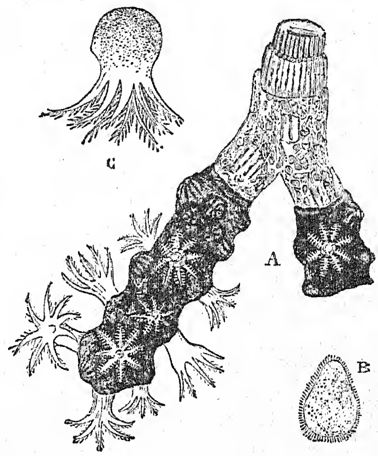


Fig. 2.—Red Coral (*Corallium rubrum*) magnified. A, Polypes; B and C, Embryos.

LIMBS.—We further notice, as regards a fish, that, in addition to the unpaired expansions or fins, which project from the middle line of the body, there are four paired fins, which may with propriety be termed limbs, *i.e.* a pair of anterior or pectoral fins and a pair of posterior or pelvic fins. These are all unjointed, paddle-shaped expansions, with quite continuous margins. Let us now turn to the Frog, which begins life as a fish-like tadpole. Fixing our attention upon an individual which is beginning to turn into a frog, we shall distinguish all the features which belong to the bilateral state; but the limbs, instead of being fin-like, are divided transversely into certain regions, and are also provided with digits. Both of these features have relation to the semi-terrestrial life which the adult is destined to lead. Taking next an adult frog, we find the limbs well-developed, while the long swimming tail which was so conspicuous a feature in the tadpole has entirely disappeared. Nevertheless the trunk clearly possesses anterior and posterior ends, while the distinction between dark dorsal and light ventral surface is equally clear. Suppose the frog now to

stand on its hind-legs in the erect attitude commonly attributed to it in illustrated books of fables and the like, and we shall see that the anterior and posterior ends of the trunk become upper and lower, while the ventral surface faces to the front, and the dorsal surface faces, if one may so speak, to the back. A frog thus disposed has a comic resemblance to a human being, and the reason is clear—the erect attitude in both cases brings about the same relative positions of ends and surfaces.

Let us next examine the two pairs of limbs possessed by Man. A very cursory inspection will show that they are divided into similar regions, and this is best expressed in tabular form—

Anterior or Fore Limbs.	*Posterior or Hind Limbs.*
1. Upper arm.	1. Thigh.
2. Forearm.	2. Lower leg.
3. Hand.	3. Foot.
(*a*) Wrist.	(*a*) Ankle.
(*b*) Palm region.	(*b*) Sole region.
(*c*) Thumb and four fingers.	(*c*) Great-toe and four others.

STRUCTURE OF THE HUMAN BODY

It was long ago pointed out by Huxley that the body, apart from the limbs, may be looked upon as a double tube. When halved longitudinally, and the internal organs removed, this can be very clearly seen (fig. 3), and the same thing is obvious in the similarly divided carcasses of sheep and other animals to be seen hanging up in a butcher's shop. The two tubes may also be clearly seen in a cross section. One of them is dorsal, the other ventral. The latter forms in the trunk the large cavity of the chest and abdomen, being divided into two parts corresponding to these two regions by a partition, the mid-riff or diaphragm, which is partly fleshy, partly fibrous. The thoracic part contains the heart, lungs, most of the gullet, and part of the large blood-vessels; while the abdominal part contains the bulk of the digestive organs, the kidneys, and various other structures. The dorsal tube in the trunk is comparatively small, and consists of a narrow canal running down within the backbone and enclosing the spinal marrow. It is continued through the neck, and in the head expands greatly into the large cavity of the cranium or brain-case, in which the brain is situated. The brain and spinal

marrow are continuous with one another. One can scarcely say that the ventral cavity is represented at all in the neck or head.

N.B.—In the following account of the human body it is supposed to be placed with the front (ventral) surface directed downwards and the back (dorsal) surface directed upwards, as in a quadruped. The "upper" and "lower" parts, commonly so called, will be termed anterior and posterior respectively, unless the ordinary words happen to be specially convenient, as *e.g.* when the arrangement for supporting the weight of the body are described.

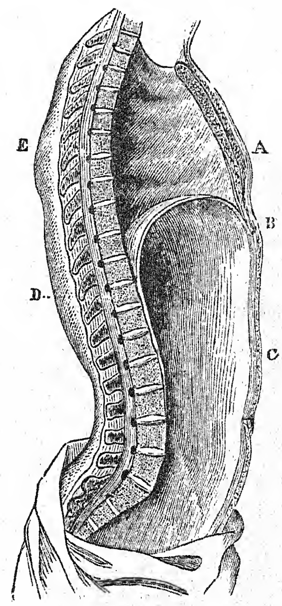


Fig. 3.—Trunk in Longitudinal Section. A, Ventral wall of thorax; B, Diaphragm; C, Ventral wall of abdomen. To right of E and D is seen backbone in section with spinal canal.

The body of a large and complicated animal such as a human being requires hard parts to serve as a protection to the delicate internal organs, to act as a stiffening or support, and to furnish points of attachment to the bands or masses of flesh (muscles) by means of which movements are effected. Such hard parts constitute the *skeleton*, which may be either external (*exoskeleton*) or internal (*endoskeleton*), both being present in many animals. In Man the *exoskeleton* is not so well developed as in many other cases, but it is present in the form of the horny outer layer of the skin (epidermis), and the hairs and nails which grow out from this. Without epidermis the numerous blood-vessels in the deeper part of the skin (dermis) would constantly be wounded, while the many nerves there ending would be the source of constant pain. Any bald-headed person can testify to the value of hair as a protection from extremes of temperature and damp, while nails help to protect the sensitive ends of the fingers and toes, though this, of course, is not their only or even their chief use.

THE ENDOSKELETON.

The endoskeleton (figs. 3–7) is built up from bone, gristle (cartilage), and tough fibrous material (connective tissue). We may conveniently distinguish between the *axial skeleton* (supporting the head, neck, and trunk) and the *skeleton of the limbs.* The

former consists of *backbone*, *skull*, *ribs*, and *breast-bone*. It will be perhaps best to begin with the first of these.

THE AXIAL SKELETON.

1. *The Backbone.*—A glance at the backbone, or, as it is often called, the *vertebral column* (fig. 4), shows that it is thrown into a series of curves, which converts it into a kind of spring for breaking the shocks to which the body is constantly liable, and which if transmitted to the brain would often result in stunning, or it might be even more serious injury. A further obvious fact is that we have not here to deal with a single bone, but a large number of them, piled on top of one another. Each of these vertebræ (fig. 5) is irregular in shape, consisting of a bung-shaped *body* (centrum) and a curved *arch* from which several projections or processes grow out. The successive bodies are placed one above the other on the ventral side of the backbone, and are separated from one another by pads of gristle which act as buffers, allowing at the same time as much flexibility as is consistent with a proper degree of firmness. Successive arches are further linked together by the overlapping of their processes. It will further be noted that in this way a kind of tunnel is formed in which the spinal marrow is lodged and efficiently protected. This is essential, for it is an exceedingly delicate organ, and any severe injury inflicted upon it would result either in death or else in paralysis of the parts posterior to the damaged region. The vertebræ differ among themselves in size and shape, and are divisible into groups belonging to different regions of the body. The first seven, beginning at the head end, are the *neck-vertebræ*, and of these the first and second have a special interest (fig. 6). The first, or *atlas*, supports the rounded skull, just as, to compare

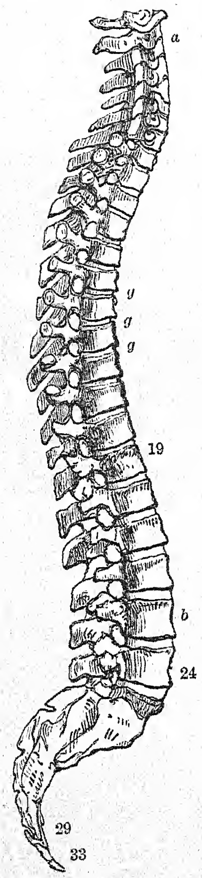


Fig. 4.—Backbone

7, 19, 24, 29, 33, Last vertebræ of neck, chest, loin, sacral, and tail regions; *a b*, ventral curvatures; *g g g*, pads of gristle between bodies of vertebræ.

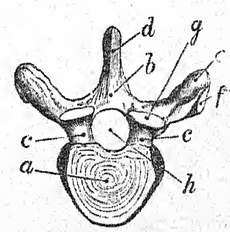


Fig. 5.—A Dorsal Vertebra

a, body; *b c*, arch; *d g*, processes; *h*, spinal canal.

small things with great, the giant Atlas was supposed to bear the globe on his shoulders. This vertebra presents two shallow cups on the side facing the skull, from which project two corresponding rounded projections. A hinge-joint is thus constituted, as a result of which we are able to nod our heads backwards and forwards. Movement from side to side would, however, be restricted by this arrangement if it were not for another one which exists to compensate it. The second vertebra, or *axis*, bears a firm bony peg, which projects through the ring-like atlas towards its ventral side and forms, as its name indicates, a pivot round which the head with the atlas can turn, too great freedom of movement being prevented by firm fibrous bands or ligaments which run from the peg to the skull. Following the neck-vertebræ come twelve rib-bearing *chest-vertebræ*, which form part of the dorsal wall of the chest-cavity. Next come five large *loin-vertebræ*, the size of which is due to the necessity for a firm support to the very considerable weight of the parts of the body coming above them. Still lower down this necessity becomes still greater, and the demand is met by a complicated basin-shaped mass of bone, the *pelvis*, the numerous arch-like curves of which are so arranged as to confer immense strength. The pelvis consists of three bones firmly fused together in the adult, the dorsal one, which alone belongs to the backbone, being the *sacrum*, made up of five broad flat sacral vertebræ immovably fused together. The last section of the backbone is a small curved structure termed the *coccyx* (Gk. for cuckoo), so named from its supposed resemblance to a cuckoo's beak, and resulting from the intimate union of four small tail vertebræ. It is chiefly interesting as being the useless representative of the tail, which is such a useful appendage in many of the lower forms.

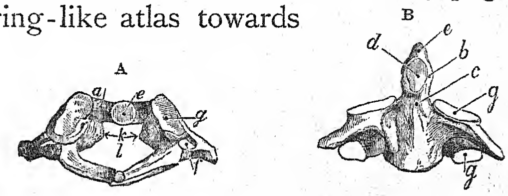


Fig. 6.—A, Atlas vertebra, anterior view, ventral surface upwards: *a e*, body; *g*, cup for reception of occipital condyle; *f*, process; *k*, position of a ligament; *l*, spinal canal. B, Axis vertebra, ventral view, anterior end upwards: *b e d*, parts of peg; *c*, anterior end of body; *g g*, processes.

2. *The Skull.*—The hard parts of the head together constitute the *skull* (see fig. 7), which consists of a brain-case, of relatively enormous size in Man, and the bony framework of the face. The *brain-case* is made up of a number of flat bones, firmly united by interlocking edges and also in part by overlapping surfaces, the net result being an arched box of very

great resisting power—a very necessary arrangement, since the contained brain, the most important organ in the whole body, is soft and pulpy. A further point of interest is found in the fact that the skull-bones possess three layers, a compact outer layer, a spongy middle layer, and a compact inner layer. Here again is another arrangement for breaking shocks.

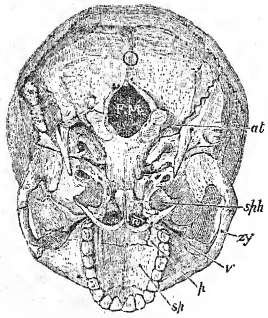


Fig. 7.—Base of Skull

FM, Foramen magnum surrounded by occipital bone; *a t*, an occipital condyle; *p*, *s p*, bony palate with teeth in a curve round margin; *n*, opening of nasal cavities; other letters refer to various bones

As previously stated, the spinal marrow is continuous with the brain, and this continuity is rendered possible by the presence of a round hole (*foramen magnum*) in the back of the cranium bounded by the occipital bone, which is really made up of four bones fused together (fig. 7). On each side of this hole is a smooth rounded prominence, or occipital condyle, which fits into a corresponding cup in the atlas vertebra. The presence of *two* condyles is an important point to notice from the classificatory stand-point.

The skeleton of face (fig. 7) is constituted by numerous bones arranged in a very complicated manner, and including as their largest elements the framework of the jaws. The two upper jawbones are the biggest, and they are firmly united together in the middle line, presenting also on the side facing the mouth a curved margin carrying the sockets for the upper teeth. The lower jawbone, or mandible, really consists of two firmly-united bones bearing the sockets for the lower teeth. It is united with the main skull by a hinge-joint, formed by two rounded projections (condyles) of the mandible, which fit into corresponding pits above. This joint varies in character in different animals in accordance with the kind of movement which the lower jaw has to execute, and this again depends upon the nature of the food and the manner of feeding. In a flesh-eating animal, such as the cat, the condyles are transversely elongated, so as to give a very perfect hinge-joint, only permitting a series of snaps. Anyone who has watched a cat or dog feeding is familiar with the kind of action indicated. A large number of familiar animals, such as rat, mouse, squirrel, and rabbit, constantly gnaw various things with their chisel-shaped front teeth, and in them the condyles are elongated from before backwards, allowing of a corresponding movement. Those forms again which

"chew the cud", *e.g.* cow, sheep, goat, are obliged to move their jaws from side to side, a kind of movement which is rendered possible by flattish condyles. In human beings the lower jaw can be moved in all three ways, and the condyles are not only convex from side to side, and from before backwards, but are set on obliquely, an arrangement which permits all varieties of movement.

The skeleton of the face is also reckoned to include another loose bone, the hyoid (so named from its resemblance to the Greek letter Ypsilon, Υ, corresponding to our U), which supports the root of the tongue, and keeps the top of the windpipe open. It possesses two pairs of horn-like projections, and is interesting as representing what is a very elaborate apparatus in such lower forms as fishes.

In the skeleton of the face there are also properly included the minute bones or ossicles which belong to the organs of hearing, and regarding which more will be said elsewhere.

3. *The Ribs*, and 4. *The Breast-bone.*—The ribs and breast-bone (sternum) complete the axial endoskeleton. These, with the thoracic part of the backbone, form a firm framework by which the heart, lungs, and other delicate structures contained in the chest are protected from injury. There are twelve pairs of ribs, jointed on to the backbone dorsally, and, except the two last pairs, connected by pieces of gristle (costal cartilages) with the breast-bone.

Skeleton of the Limbs.—Turning to the skeleton of the limbs (see p. 196), we find that, both as regards the arm and leg, we can distinguish between (*a*) a firm bony girdle by which the base of the limb is connected with the trunk, and (*b*) the hard parts within the free or movable portion of the limb. In the case of the arm we have a *shoulder-girdle* consisting of two bones, the broad triangular shoulder-blade (scapula), placed dorsally and firmly bound by muscles to the trunk skeleton, and the collar-bone (clavicle), which runs across from scapula to sternum. One corner of the triangular scapula is provided with a shallow cup, the *glenoid cavity*, into which the rounded end of the upper-arm bone fits so as to form a ball-and-socket joint, which allows of very free movement. It is important to notice a bony projection which overhangs the glenoid cavity, and which, from a supposed resemblance to the beak of a raven (Gk. *kŏrax*,

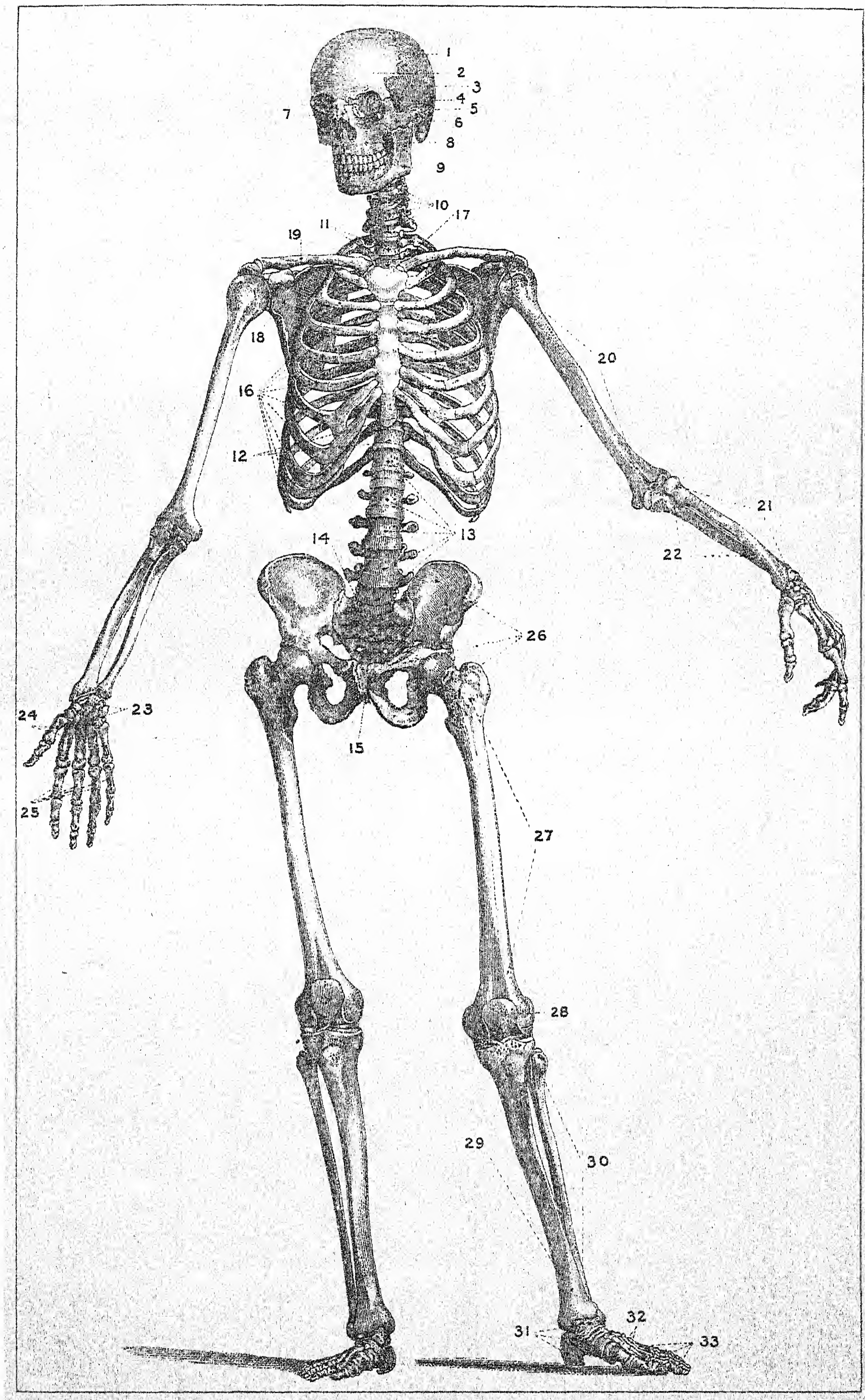
a raven), has been named the *coracoid process*. Here again we have a vestige of what is an important structure elsewhere, representing as it does the coracoid bone, which, in such a creature as a bird, is as large as the scapula and quite distinct from it.

1. *Arm.*—The arm itself is supported by a number of bones, many of which belong to the class of long bones, and of which we may take the *humerus*, or upper-arm bone, as a typical example. This consists of a hollow marrow-containing shaft, and swollen extremities presenting smooth gristle-covered surfaces well adapted for entering into the formation of joints. The shaft is a good example of the mechanical device of the hollow column, presenting the advantages of lightness and economy of material without loss of strength. The thickened ends are made for the most part of spongy bone, consisting of layers arranged in such a way as to combine great strength with lightness, while at the same time the transmission of shocks is very largely hindered. As already mentioned, the upper end of the humerus helps to form the ball-and-socket-like shoulder-joint. At its lower end is a pulley-shaped surface, which, in combination with the two long bones of the forearm, gives the hinge-like character to the elbow-joint. These bones are known as the radius and ulna, the former being on the thumb-side, and the latter on the little finger side. The upper end of the ulna is large, projecting behind the elbow as what is popularly called the "funny bone", but is in reality not a separate bone at all. The lower end of the ulna is comparatively small. Exactly the reverse is true of the radius, which is small at its upper end, but large at its lower end, where it has to support the hand. And here we find a point of great interest. The fore-arm is capable, as is known to everyone, of a rotatory movement whereby the hand can be turned with its back upwards, the position of *pronation*, as contrasted with the position of *supination*, in which the palm is upwards. In the latter position the ulna and radius are parallel, but in the former the radius, carrying with it the hand, crosses obliquely over the ulna. Such an arrangement obviously adds vastly to the use of the hand and arm, and is absent in those animals where the fore-limbs are used mainly for locomotor purposes.

The *wrist* is supported by eight small irregular bones, arranged so as to combine strength with flexibility, as well as to break the shocks to which the hand is especially liable. They are succeeded

THE HUMAN SKELETON

1. Parietal bone.
2. Frontal bone.
3. Temporal bone.
4. Orbit.
5. Side of occipital bone.
6. Malar, or cheek-bone.
7. Nasal bone.
8. Upper jaw-bone.
9. Lower jaw.
10. Four lower neck (cervical) Vertebræ.
11. Two upper chest (thoracic) Vertebræ.
12. Two lowest chest (thoracic) Vertebræ.
13. Loin (lumbar) Vertebræ.
14. Sacrum.
15. Coccyx.
16. Ribs.
17. Breast-bone (Sternum).
18. Shoulder-blade (Scapula) } Shoulder
19. Collar-bone (Clavicle) } Girdle.
20. Humerus.
21. Radius.
22. Ulna.
23. Wrist-bones (Carpus).
24. Palm-bones (Metacarpus).
25. Finger-bones (Phalanges).
26. Hip-bones, Hip Girdle.
27. Thigh-bone (Femur).
28. Knee-cap (Patella).
29. Shin-bone (Tibia).
30. Clasp-bone (Fibula).
31. Ankle-bones (Tarsus).
32. Instep-bones (Metatarsus).
33. Toe-bones (Phalanges).



THE HUMAN SKELETON

by five elongated bones, which support the palm, and from their shape are classed with the long bones. Fourteen small phalanges of similar shape complete the skeleton of *the hand*, each finger possessing three, while the thumb has only two. Each end-phalanx is broadened out and roughened at its tip to afford a support to a nail.

Two further points of interest deserve mention in regard to the hand. One is the unequal lengths of the *digits* (or fingers), a device which renders them much more efficient in delicate manipulations, enabling their tips to be brought together with great ease. The other point is the opposability of the thumb, *i.e.* it can be bent over so as to directly oppose any one of the fingers. How important a matter this is may be realized by trying to pick up a small object, say a pin, by means of the fingers alone. The arrangement is rendered possible by the peculiar nature of the joint between the base of the thumb and the wrist. The opposing surfaces are here saddle-shaped, allowing a much larger range of movement than any other combination of curves. The same kind of jointing is found in a bird's neck, which is well known to be exceedingly flexible.

2. *The Leg.*—Here we find in the first place a *hip-girdle*, comparable to the shoulder-girdle of the upper limb. But the necessity for supporting the very considerable weight of the body has in this case brought about an intimate union with the skeleton of the trunk, and the two girdles are firmly united with one another and with the *sacrum* to form the basin-like *pelvis* mentioned above (see p. 27). Each girdle is constituted by an irregular hip-bone, consisting of three elements fused together, and corresponding to what in many animals are clearly to be distinguished as three separate bones. The pelvis is arched so as the better to support the weight of the body transmitted to it, and thence to the thigh-bones, by means of the sacrum, which may be compared to the keystone of the arch. A further use of the pelvis is to protect certain delicate internal organs placed within its cavity.

On the outer side of each hip-bone is a deep cup for receiving the globular upper end of the large *femur*, or thigh-bone, which is comparable to the humerus in the upper arm. The joint at the thigh, like that at the shoulder, is of the ball-and-socket kind, but here greater firmness is necessary, and consequently less

freedom of movement is permitted, the cup being much deeper and the union by fibrous bands more intimate.

The lower end of the femur helps to form the hinge-like knee-joint in conjunction with the shin-bone (*tibia*) of the lower leg, which corresponds to the radius in the forearm. The front of this joint is protected by a round and somewhat flattened bone, the *patella* or knee-pan. There is nothing corresponding to this in the elbow.

The chief bone of the lower leg is the *tibia*; but there is also a second much slenderer one, the *fibula*, corresponding to the ulna in the forearm, but not helping to form the knee-joint. Just as the wrist is supported by a number of irregular bones, so is the *ankle*, but as these have to support the weight of the body they are relatively much larger and stronger. Following them come five sole-bones, corresponding to palm-bones; while the toes, like the fingers, are completed by fourteen phalanges, which, however, are relatively short. The great toe is not opposable and is very much larger than the others, since it plays an important share in supporting the weight of the body. It may be remarked that the skeleton of the foot presents an arch from before backwards, and another from side to side, an arrangement which combines great strength with a large amount of springiness. The weight of the body falls mainly on the heel, toes, and outer side of the foot.

NUTRITION.

The body is constantly undergoing waste, and also, in the earlier part of life, increasing in volume, or growing. This waste must be counterbalanced and materials for growth provided; hence the necessity for food, which may be compared to the materials used for repairing a machine and, it may be, making additions to it. And just as the original nature of a machine determines the material to be employed, so also in the case of the body. In other words, if we are to understand the nature of the food, we must have some knowledge of the composition of the body.

Chemical Composition of the Body.—When the body of an animal is acted upon by intense heat most of it is dissipated in the form of gas, the comparatively small remainder, or ash, consisting of various mineral matters. The gaseous portion, when

further analysed, is found to contain the four elements, Carbon, Hydrogen, Oxygen, and Nitrogen. It is therefore to be expected that our food should consist in the main of compounds of the same four chemical elements[1], and this is actually the case. Obviously this must be so for the fleshy part of the food, and it is also true for the vegetable portion. The different kinds of food may be classified as follows:—

1. *Nitrogenous Food*, consisting, in ultimate analysis, of carbon, hydrogen, oxygen, and nitrogen, together with sulphur, and in some cases phosphorus. Such foods are of exceedingly complex chemical nature, and may broadly be called *proteids* or *albuminoids*[2]. The last name is taken from albumin, of which white of egg may be considered as a type; while egg-yolk, lean meat, blood, gelatin, and cheese are of the same nature in whole or part. An example from the vegetable kingdom is gluten, the sticky constituent of flour, to which the tenacious character of dough is chiefly due.

2. *Non-nitrogenous Food*, as the name indicates, contains no nitrogen. Its various kinds are:—

(*a*) *Carbohydrates*, containing carbon, hydrogen, and oxygen, and including starch, sugar, gum, &c.

(*b*) *Hydrocarbons*, or fats and oils, consisting of the same three elements, arranged, however, in different proportions.

(*c*) *Mineral Salts*, including compounds of lime and iron, as well as common salt (sodium chloride). The more complicated foods enumerated under the preceding headings contain a varying amount of such mineral compounds, which have, however, to be supplemented in Man and various other animals by common salt. The importance of salts of lime becomes apparent when we remember that the hard part of bones and teeth consists of them.

(*d*) *Water*, consisting of hydrogen and oxygen, and generally containing mineral salts dissolved in it. Water is not only taken in the form of drink, but also forms an important constituent of albuminous, starchy, and fatty foods.

This complex food, unlike the food of plants, which is entirely gaseous or liquid, is largely taken into the body in the form of

[1] A chemical element is a substance which cannot, so far as we know, be resolved into components of different nature.

[2] The term *albuminoid* is often used in a narrower sense than this.

solid or semi-solid fragments, hence the necessity for an internal digestive cavity, the possession of which is characteristic of a higher animal as contrasted with a higher plant. In Man, for example, we have a set of digestive organs, the function of which is to deal with this crude food and reduce it to such a condition that it can be utilized for repair and growth, or, in other words, to digest it.

DIGESTIVE ORGANS.—These consist essentially of a long digestive tube, more briefly termed the gut, into which a number of structures known as digestive glands pour fluids.

1. *The Gut.*—The gut (figs. 8 and 9) is of very unequal width in different parts of its course, and, being very much longer than the body, is only able to pursue a straight course from the mouth

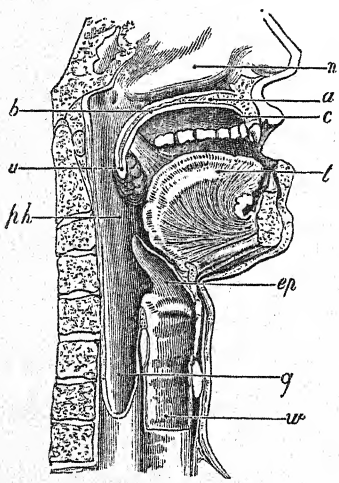


Fig. 8.—Section showing Mouth and Nasal Cavities, Gullet, Windpipe, &c.

a, Hard palate; *b* to *u*, soft palate; *c*, mucous membrane; *n*, cavity of nose; *t*, tongue; *ph*, pharynx; *g*, gullet; *ep*, epiglottis; *w*, windpipe.

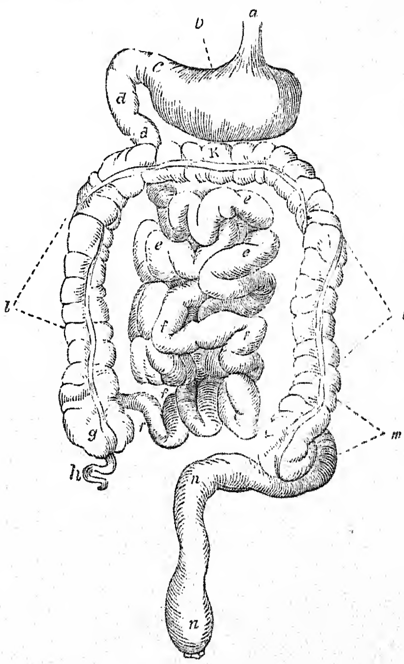


Fig. 9.—The Gut

a, Gullet; *bc*, stomach; *def*, small intestine; remaining letters indicate parts of large intestine.

to the end of the thorax, while in the abdomen it is largely coiled. The mouth, bounded by fleshy lips, leads into the fairly large mouth-cavity, marked features of which are the teeth and muscular tongue. At the back of this cavity is the pharynx, communicating with the cavities of the nose and ear; while on its floor is an opening, the glottis, leading into the breathing organs. The pharynx may be looked upon as the dilated front

end of a narrow muscular tube, the gullet, which succeeds it, and, running along the neck and through the thorax, pierces the midriff, to become continuous with the large transversely-placed stomach, which has thick muscular walls. This in its turn is succeeded by a very long thin-walled tube, the small intestine, followed by a shorter but broader large intestine, which ultimately opens to the exterior.

The whole of the gut is lined by the mucous membrane, a soft reddish skin richly provided with blood-vessels.

2. *The Teeth* (figs. 10 and 11).—These deserve further mention, as they present interesting adaptations to the food and mode of feeding, while their number and form furnish important characters for purposes of classification.

All the teeth are imbedded in sockets, the imbedded part being the fang, while the projecting portion constitutes the crown. The greater part of a human tooth is composed of a very hard substance, dentine, within which is hollowed out a cavity for the sensitive pulp, richly provided with blood-vessels and nerves. The fang is covered by a layer of bony material, cement, while the crown is invested by an intensely hard substance, the enamel. It is a matter of common knowledge that there are two sets of teeth, the first or milk set consisting of twenty teeth, which are replaced by the thirty-two teeth making up the permanent set. Beginning with the latter, we find in the front of the jaws eight chisel-edged incisors adapted for dividing food. Outside these are the four pointed eye-teeth or canines, which in such creatures as cats and dogs play an important part as weapons and holdfasts. Lastly come the

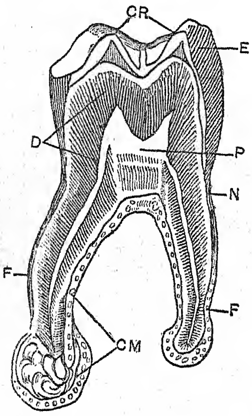


Fig. 10.—Section of a Tooth
Cr., Crown; N, neck; FF, fangs; P, pulp cavity; E, enamel; D, dentine; Cm., cement.

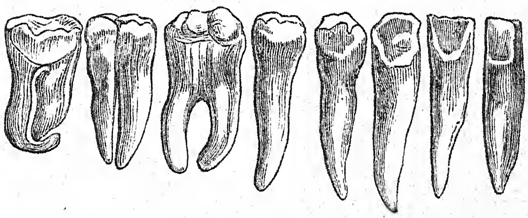


Fig. 11.—Kinds of Teeth
This figure shows the eight teeth in one half of a jaw.

broad-crowned cheek-teeth, twenty in number, of which the first eight are known as bicuspids or premolars, while the remainder are called molars. All this may be expressed by a dental formula as follows:—

$$i. = \frac{2-2}{2-2},\quad c. = \frac{1-1}{1-1},\quad p.m. = \frac{2-2}{2-2},\quad m. = \frac{3-3}{3-3} = 32.$$

[*i.* = incisor, *c.* = canine, *p.m.* = premolar, *m.* = molar.]

Each fraction corresponds to one kind of teeth, the numerator representing upper and the denominator lower ones, while the dashes above and below mark the distinction between teeth on the right and left side. Since these structures are symmetrically arranged it is only necessary to represent those of one side, and so it is convenient to shorten the formula to—

$$\frac{2.1.2.3}{2.1.2.3} \times 2 = 32.$$

In the first or milk set the incisors, canines, and premolars are represented respectively by milk incisors, milk canines, and milk molars, while the molars of the permanent set have no predecessors.

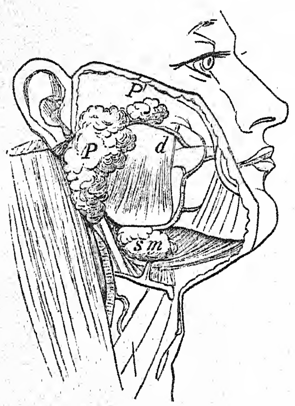


Fig. 12.—The Salivary Glands

P P', Parotid; *sm*, sub-maxillary. *d* is placed below the duct of the parotid.

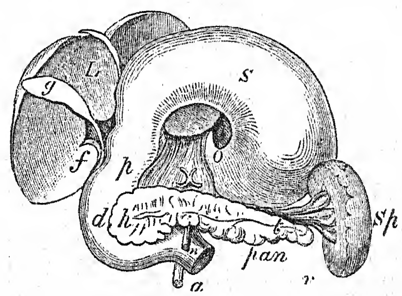


Fig. 13.—Relations of the Stomach to the Liver, Pancreas, and Spleen

o s p, Stomach; *d*, small intestine; L, liver; *g*, gall-bladder; *f*, placed to left of bile-duct; *h*, *t*, pancreas; *sp*, spleen; *v*, placed below blood-vessels of spleen; *a* and *n*, blood-vessels.

3. *Digestive Glands* (figs. 12 and 13).—These elaborate or secrete different fluids, which act chemically upon the food. Opening into the mouth-cavity are three pairs of soft masses, the *salivary glands*, which secrete the spittle or saliva. One pair is placed in front of the ear (parotid), and it is these structures which swell up and become painful in cases of mumps. A second pair (sub-maxillary) are placed between the halves of the lower jaw, while the third and much smaller pair (sub-lingual) are imbedded in the deeper part of the tongue.

Other very important organs of the kind, the *peptic* or *gastric glands*, are found as innumerable minute branching tubes opening into the stomach, in the lining of which they are imbedded. The fluid secreted by these glands is the gastric juice.

The *liver*, which is the largest organ of the body, is, among other things, a digestive gland. It is a bulky reddish-brown mass placed in the upper part of the abdominal cavity, and its secretion, the bile or gall, passes into the beginning of the small intestine through a small thick-walled tube, the bile-duct. Connected with this is a pear-shaped bag, the gall-bladder, in which bile can be temporarily stored up.

The last digestive gland of importance is the *pancreas*, popularly known as the sweetbread, which lies in the first loop made by the small intestine, and pours its secretion, the pancreatic juice, through a short tube into the bile-duct.

PROCESS OF DIGESTION.—The process of *Digestion* essentially consists in the conversion of food into a dissolved or else a very finely-divided state. It is effected partly in a *mechanical*, partly in a *chemical* manner.

1. *Mechanical Digestion.*—As regards mechanical digestion an important part is played by the teeth, which reduce the food to small fragments, this being rendered more easy by the pouring out of saliva, which acts as a moistening and softening agent. The muscular tongue and cheeks are also of importance here, because they help to keep the fragments between the grinding teeth. In gullet, stomach, and intestines a further division is brought about as the result of a squeezing action exerted by the muscle-containing walls of these organs.

2. *Chemical digestion* is even more important. Within the stomach abundant gastric juice is poured on to the digesting food and acts more particularly upon the albuminoids, converting some of them into a soluble form known as peptone.

The *saliva* is concerned with starchy foods, which it converts into a kind of sugar.

Chemical digestion is completed in the small intestine by the *bile* and *pancreatic juice.* The latter finishes the work on the starchy and albuminous matters begun by saliva and gastric juice, besides which it acts on fats, converting them into a milky state or emulsion, where minute globules of the fat are suspended in fluid. The bile helps in the digestion of fats, and is of importance in

several other ways, *e.g.* it prevents the digesting food from becoming putrid.

The digested foods are now absorbed into the minute blood-vessels which branch in the mucous membrane, the digested fats, however, passing into other minute tubes called lacteals, which ultimately communicate with the blood-system. It must, of course, be understood that blood-vessels and lacteals do not open into the cavity of the gut, but the digested materials, so to speak, soak into them. Those parts of the food which are not digested pass out of the body altogether.

CIRCULATORY ORGANS

Branching elaborately within the body, and sending its twigs into almost all its different parts, is a closed set of tubes constituting the blood-system. Propelled by the heart or central pump the red fluid known as blood is constantly circulated through this system. Supplementary to the blood-system we have a set of spaces and tubes (of which the lacteals mentioned above form a part) making up the lymph-system. This contains a pale fluid, the lymph, which it pours into certain of the great blood-tubes. The two fluids, blood and lymph, especially the former, may be regarded as a sort of medium of exchange as regards the various parts of the body. Certain things are taken out of them to meet local requirements, and certain other things pass into them.

Speaking more precisely, the functions of the circulatory system are as follows:—(1) It distributes the digested food, *i.e.* the materials for repairing waste and providing for growth; (2) It removes waste matters from all parts of the body, and carries these to organs which can get rid of them; (3) It carries oxygen to promote this waste; and (4) It distributes heat and equalizes the temperature of different parts.

THE BLOOD (figs. 14 and 15).—When examined under the compound microscope a drop of blood is found to consist of colourless liquid (plasma) in which float a vast number of minute bodies, the *blood-corpuscles.* These are of two kinds—red, and colourless or white. The former are biconcave discs not more than $^1/_{3200}$ of an inch in diameter, and they owe their colour to the presence of a peculiar pigment (hæmoglobin) that, as we shall presently see, is of great importance in respiration. The white or colourless

corpuscles are less numerous but somewhat larger ($^1/_{2300}$ of an inch in diameter), and possess the power of spontaneous movement by thrusting out lobes of the semi-fluid substance (protoplasm) which composes them. They are thus enabled to slowly crawl, as it were, along the walls of the blood-vessels. In the middle of each such colourless corpuscle is a particle of somewhat different chemical nature, the nucleus, and this is probably to be regarded as a modification of the substance composing the rest of the corpuscle. No such particle can be discerned in a human red corpuscle, which is therefore said to be non-nucleated, a character which happens to be one of classificatory importance.

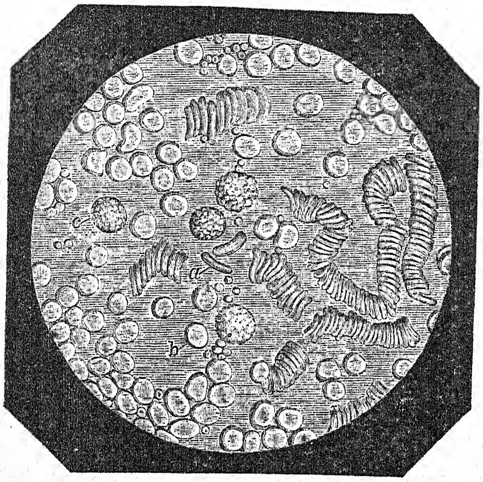


Fig. 14.—A Drop of Blood, seen under a microscope magnifying by 350 diameters

a and *b*, red corpuscles. *c*, white corpuscle.

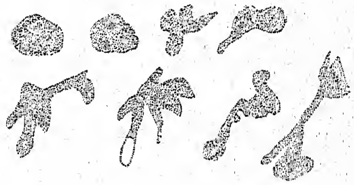


Fig. 15.—White Blood Corpuscle. Its successive changes of shape.

THE HEART AND BLOOD-SYSTEM.—This very complicated organ is in principle a force-pump possessing an internal set of valves which only permit fluid to pass in certain directions. The blood-vessels which carry blood to it are veins, while those which carry it away are arteries. To understand the heart's action it is necessary to consider the simplest case, that of a heart with only one chamber or cavity (fig. 16). We may represent such a heart by an india-rubber syringe with a tube at each end, one for carrying fluid in and the other for carrying it out. There must also be, at least at one end, an internal valve consisting of a flap which readily permits fluid to pass in one direction but resists its passage in the other. In such a simple model the central swelling will represent the heart, while the tube conveying fluid into it will play the part of a vein, and the other tube the part of an artery. Propulsion of fluid will be

brought about by squeezing with the hand. An actual heart requires, of course, no squeezing from outside, its walls moving in such a way that the internal cavity is alternately diminished and increased in size. This is due to the fact that its substance is made up of slender muscular fibres arranged in a very complicated fashion. Each fibre possesses the power of contraction, *i.e.* it is able to shorten itself, becoming at the same time thicker. It is clear, therefore, that if a large number of such fibres arranged transversely and obliquely to make up the wall of a hollow structure contract at the same time, the result will be that the contained cavity becomes smaller, regaining its original size when the fibres again relax. This is what happens in the case of a heart, enabling it to do pumping work.

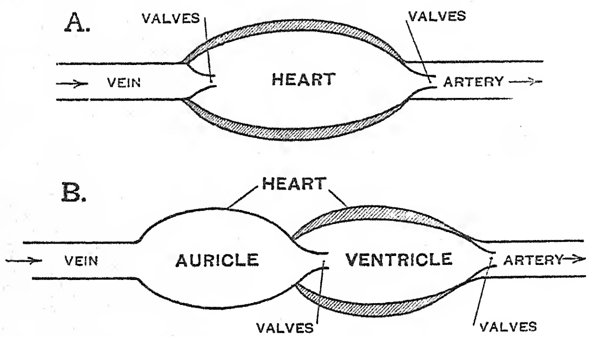


Fig. 16.—Diagrammatic Hearts. A, One-chambered; B, two-chambered.

An advance upon the simple one-chambered heart as just described is found in such a case as the common garden snail, where there are two chambers (fig. 16), one a thin-walled *auricle*, receiving blood from the vein, and squeezing it on into a thick-walled *ventricle*, which does the pumping work.

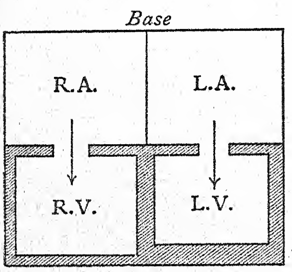


Fig. 17.—Diagram of Auricles and Ventricles

R A and L A, Right and left auricles; R V and L V, right and left ventricles.

The heart of a human being, however, has two sets of pumping work to do—(1) it forces pure blood all over the body, and (2) it drives impure blood to the lungs for purification. It is therefore not surprising that in such a heart there are four chambers, right and left auricles, and right and left ventricles, disposed as shown in the accompanying diagram (fig. 17). The right side of the heart contains only impure blood which it receives from the great veins, which open into the right auricle. This chamber passes the blood on to the right ventricle, which pumps it through a large vessel (pulmonary artery) to the lungs. These purify the blood, and from them it is conducted through pulmonary veins to the left

auricle, from which it enters the left ventricle in order to be pumped through a great artery to the body at large. This artery is known as the *aorta* (Gk. *aeirō*, I carry), and it is characteristic for the group of animals to which Man belongs, *i.e.* the Mammalia, that the curved part or arch with which the aorta begins should turn to the left. In a Bird it would be found curving round to the right.

If the *aorta* be traced, its arch will be found to give off large branches to the anterior part of the body, after which it bends into the middle line, and (as the dorsal aorta) runs just ventral to the backbone, supplying the parts it passes, and ending posteriorly by forking into two great vessels for the lower limbs. Any branch artery farther traced will be found to divide, tree-like, into smaller and smaller twigs, which at last pass into a close net-work of excessively minute thin-walled tubes, the *capillaries*. The same thing will be observed on tracing the pulmonary artery. It may, in fact, be said that almost all parts of the body are traversed by a dense net-work of capillaries, and from these the smallest veins arise, uniting, river-like, into larger and larger trunks till the great veins opening into the heart are constituted. We may therefore say that the heart and blood-vessels form a closed set of tubes, as the capillaries intervene between the smallest arteries and the smallest veins. This may be clearly seen in the web of a frog's foot.

Capillaries are of enormous importance, because their thin walls permit exchanges between the blood they contain and the body-substance they traverse.

The veins of the stomach, intestine, and certain other parts unite into a large portal vein, which enters *the liver*, and there divides up into smaller and smaller branches. The blood in this vein contains most of the digested food which has been absorbed from the gut, and the object of passing it through the liver is to let that organ take up some of these products, and store them for distribution as needed. The impure blood from the liver itself is poured by several blood-vessels into one of the great veins running to the right auricle. The arrangement just described for supplying the liver with impure blood, in addition to the pure blood which it gets from a branch of the aorta, is called the portal circulation.

THE LYMPH-SYSTEM.—The circulatory organs include a *lymph-system* as well as a blood-system. The *lymph* is a clear,

colourless fluid, consisting of plasma and colourless corpuscles. It is contained in the large internal cavities of the body, in minute crevices which exist in the substance of the various organs, and in delicate *lymphatic vessels* which ramify in most

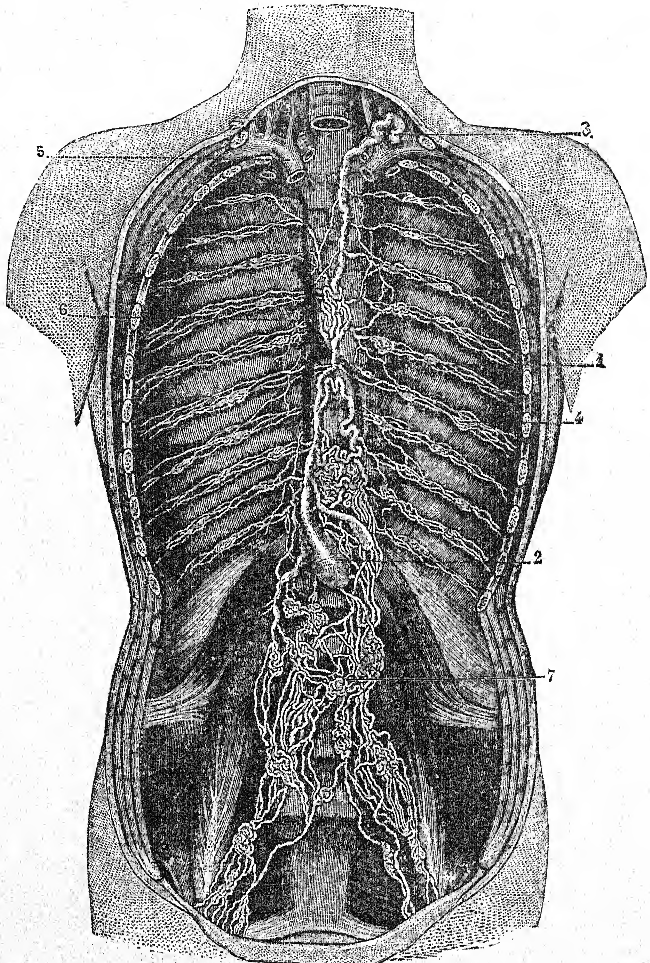


Fig. 18.—The Thoracic Duct and Lymphatic Vessels. 3 1 2, The duct, opening into great veins at 3.

parts of the body. Those of the intestines are termed *lacteals*, and receive the digested fats. Most of the lymphatics ultimately open into the thoracic duct (fig. 18), a narrow tube lying ventral to the backbone, and opening on the left-hand side into the great veins at the base of the neck. In this way the blood receives the digested fats, and a constant supply of colourless corpuscles.

The so-called *ductless glands* are related to the lymph-system. The largest of them is the dark-red milt or *spleen* (fig. 13), situated close to the stomach. It has to do with the destruction of worn-out red corpuscles. The *thyroid gland* is closely applied to the ventral side of the larynx, and is notorious as the organ which swells up in cases of Derbyshire neck (goître). It has been proved to be of importance in regulating the nutrition of the body. The *thymus gland* is a fatty-looking mass wrapped round the base of the heart, and much larger in infants than in adults. In the early stages of life it is one of the chief sources of colourless corpuscles.

Lymphatic glands are little swellings placed here and there in the course of lymphatics (fig. 19). New colourless corpuscles are constantly being formed in them.

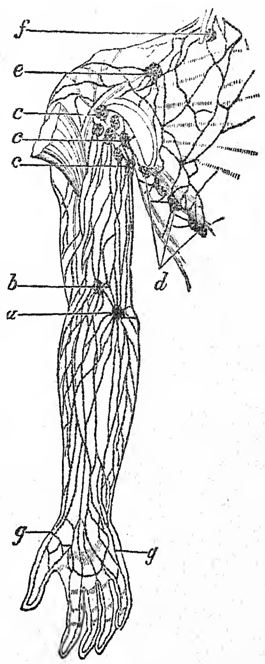


Fig. 19.—Lymphatics of the Arm and Arm-pit

Glands at the inner side of the elbow, *a b*; in the arm-pit, *c c c*; on the chest in front of the arm-pit, *d*; above the collar-bone and communicating with the arm-pit, *e f*. *gg* point to lymphatic vessels forming an arch round the hand. The dark lines are lymphatic vessels.

WASTE-REMOVING ORGANS

The living substance making up the body of an animal is constantly undergoing a process of change, whereby it breaks down into simpler compounds. We have, in fact, two sets of chemical changes constantly going on within the body:—

(*a*) A series of upbuilding or constructive processes whereby the food is gradually converted, step by step, into the substances which constitute the body, and of which the most complex is the living material known as protoplasm. This series of chemical changes is comprised under the head of *assimilation* (L. *adsimilo*, I make like), *i.e.* processes whereby the body makes the material taken in as food into fresh substance like itself. Assimilation is most naturally dealt with under the head of Nutrition.

(*b*) The other set of chemical changes within the body are destructive in nature, involving the down-breaking of material, partly of protoplasm itself, and partly of other less complex compounds. These changes have been called "local death", and

are absolutely essential to life, for without them life would be impossible. Every manifestation of vitality by an organism, such as movement, production of digestive or other secretions, sensations, and mental operations, involve the breaking down or waste of material, without which the necessary energy would not be available. Broadly speaking, energy is the power of doing work, and a distinction is drawn between potential or stored energy and actual or kinetic energy. Complex chemical substances, such as high explosives, represent a store of energy, and when these break down into simpler substances, *i.e.* explode, a large amount of actual energy is liberated, which, in the case of the explosives alluded to, can be made to do various kinds of useful work. Protoplasm and the other complex body-substances are, so to speak, of explosive nature. The final results of these down-breaking changes are waste products, which have to be eliminated or excreted from the system. The accompanying diagram (fig. 20) illustrates the matter. It represents a double staircase, with a shorter ascending stair on the left, and a longer descending stair on the right. Food is represented as being on the level of the lowest step of the left-hand stair, the successive steps of which represent the stages by which more and more complex substances are built, till the most complex of all, protoplasm, is produced. The breaking down of this into simpler and simpler substances is represented by the successive steps of the descending stair, at the bottom of which are the waste products. These are represented at a lower level than the food, because they are of simpler chemical constitution. They are mainly—water (H_2O), carbonic acid gas (CO_2), and compounds of nitrogen.

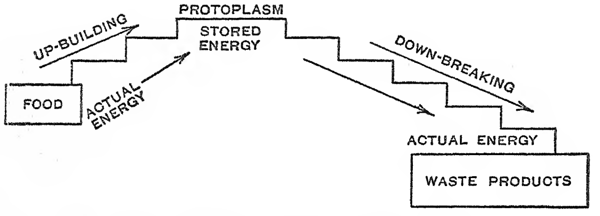


Fig. 20.—Diagram of chemical changes in Body

The organs which get rid of waste are (1) skin, (2) lungs, (3) kidneys, and (4) liver.

1. The Skin, among its other functions, eliminates a large amount of water and small quantities of the other kinds of waste, here constituting the excretion called sweat or perspiration. Imbedded in it are innumerable sweat-glands, in the form of

minute coiled tubes, each opening by a very small pore on the surface. The coiled part of each such gland is sunk deeply in the dermis, and is surrounded by capillary blood-vessels, from the blood contained in which the materials making up sweat are separated.

2. THE LUNGS (fig. 21) are two spongy bodies contained in the thorax, and their function as breathing or respiratory organs is twofold—(1) to excrete or get rid of the waste carbonic acid gas, together with a large quantity of water, and (2) to supply the blood with free oxygen, which is necessary as the agent by which the waste constantly going on in the body is rendered possible. This waste is in fact a process of oxidation, *i.e.* a conversion of protoplasm, &c., into simpler bodies containing a larger proportion of oxygen. The lungs are spongy in character because they are made up of innumerable little air-tubes, ending blindly in groups of minute air-sacs, with walls invested by a close network of capillaries, the blood contained in which is so near to the air in the air-cells that an exchange of materials is possible. On the one hand, a large amount of the carbonic acid gas with which the impure blood is highly charged is able to diffuse into the air-sacs, from which, on the other hand, the oxygen of the air is able to diffuse into the blood. The *hæmoglobin* of the red corpuscles plays an important part as an oxygen-carrier, taking it up from the air in the lungs and readily parting with it to the substance of the body. A large amount of water in the form of vapour also diffuses out of the blood into the air-sacs. As a result of this, the air breathed out contains far more carbonic acid gas and water-vapour, but much less oxygen, than the air breathed in. This exchange of gases constitutes the essential part of breathing; but the mechanical part has also to be considered, *i.e.* the arrangements by which the air-passages of the lungs

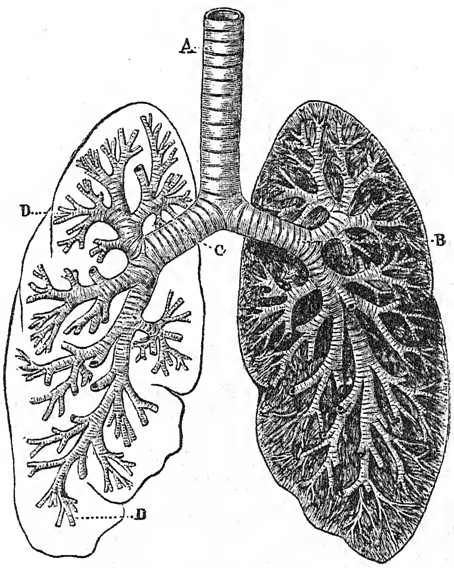


Fig. 21.—Lungs and Air-passages
A, Windpipe; B C, bronchi; D D, smaller air-passages.

are continually provided with fresh pure air, and get rid of impure air. Without going into unnecessary detail, it may be pointed out that the walls of the chest are movable, so that the size of that region is alternately increased (when air is breathed in) and diminished (when air is breathed out). During the former process, the breast-bone and ribs are moved on the joints by which the latter are hinged to the backbone, in such a way as to increase the volume of the chest from side to side and from front to back. The general nature of these movements can be easily noted by the reader in himself. At the same time the muscular midriff or diaphragm, which separates the chest from the abdomen, and in a state of rest is convex towards the former, flattens out as a result of its own contraction, and thus increases the size of the chest in the direction of its length. As the thorax is, so to speak, an air-tight box, the contained lungs are obliged to expand as it increases in volume, the result being that air passes into their larger air-passages. The reverse process to the one described, whereby diminution of volume is effected, is largely due to the elasticity of the thoracic walls, while at the time the diaphragm ceases to contract, and resumes its normal curved shape. Air consequently passes out from the larger air-passages. Purification of the air contained in the smaller air-passages (bronchial tubes) and their blind endings is brought about by diffusion. A few words are necessary on the direction taken by the air. The proper course for this (fig. 8) is through the nostrils, into the nasal cavities, and thence by a special aperture (posterior nares) into the pharynx, on the floor of which is a slit-like opening, the glottis, leading into the windpipe. Of course breathing can also be effected through the mouth, but the primary use of this is as a food-passage.

In front of the glottis there is an elastic flap, the *epiglottis* (fig. 8), which, when food is swallowed, folds back over the glottis and forms a sort of bridge to the gullet. The windpipe (trachea), into which the glottis leads, is a good-sized tube (fig. 22), with its walls stiffened by hoop-like pieces of gristle and so prevented from collapse. It can easily be felt in the front of the neck, from which it runs into the thorax, there bifurcating into a bronchus for each of the lungs. Either bronchus when traced is found to divide repeatedly to form smaller and smaller air-passages, the smallest of which end, as

already described, in delicate air-sacs. The advantage of this arrangement is to provide a very large surface over which the blood can be purified without taking up a large amount of room.

It is interesting to notice that the lungs are developed as outgrowths from the pharynx, which are at first simple pouches, but gradually become more complicated.

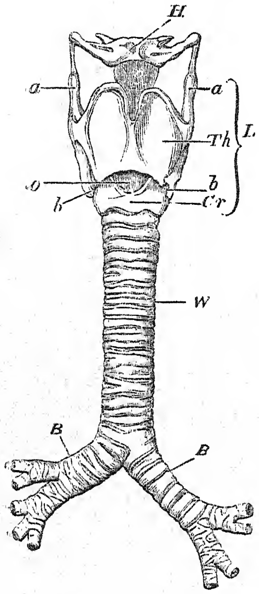


Fig. 22.—The Larynx and Windpipe

L, Larynx, formed of *Th* and *Cr*, thyroid and cricoid cartilages; *a a b b*, parts of thyroid; H, hyoid bone; *e*, epiglottis; W, windpipe; B B, bronchi.

The *organ of voice* falls to be mentioned here, since it is intimately associated with the air-passages. The beginning of the windpipe is dilated into a voice-box or *larynx* (fig. 22), supported by various pieces of gristle, of which the largest (thyroid cartilage) can be felt in the swelling known as "Adam's apple". Projecting into the cavity of the larynx are two narrow elastic cushions with sharp edges, which can be brought parallel to one another by appropriate muscles. If, when this has been done, air is sharply breathed in or out, a musical note results, and the cushions in question, commonly but rather inappropriately called the *vocal chords*, can be stretched to different extents, so that the resulting note varies in pitch, a low note being produced when they are slackened, and the opposite when they are pulled tight. Vowel sounds of various kinds are produced by altering the shape of the mouth-cavity through which the air breathed out is passed, while consonants result from momentarily blocking the air-current in different ways. The entire mechanism is extremely complicated, and this is not the place to describe it more fully.

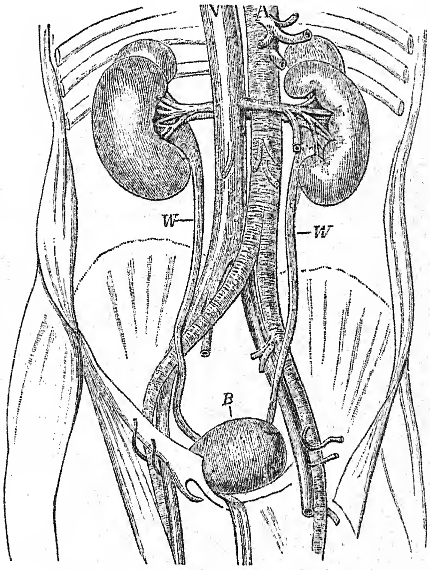


Fig. 23.—The Situation of the Kidneys

A, Dorsal aorta; V, vena cava; B, bladder; W, ureters. Branches of the aorta are seen going to the kidney, and veins from it are shown joining the vena cava.

3. The Kidneys.—The kidneys are generally described as the excretory organs *par excellence*, the useless matter here being nitrogenous waste and mineral salts dissolved in a large bulk of water. They are two characteristically-shaped structures placed in the abdominal cavity (fig. 23) close to the ventral

side of the backbone, and from each of them a tube, the ureter, conducts the products of waste to a good-sized bag, the urinary bladder, which is sheltered in the cavity of the pelvis and opens to the exterior.

4. The Liver.—Nitrogenous waste is got rid of chiefly by the liver and kidneys. The liver, which has already been described as a digestive gland, is also a waste-eliminating organ, for bile is a waste product as well as a digestive juice.

ORGANS OF MOVEMENT.

1. Muscular Action.—The obvious movements of the body are brought about by the masses of flesh technically known as *muscles*, which make up a large proportion of its weight. These muscles are of various shapes, in accordance with the differences in their uses; but they all agree in being composed of vast numbers of microscopic fibres which, under the control of the nerves, are able to contract, *i.e.* to shorten, while at the same time they become broader. The result is, that the parts to which the ends of an elongated muscle are fixed are brought nearer together. Such a muscle is generally attached at one end (the origin) to a relatively fixed part, and at the other (the insertion) to a relatively movable part. This is the case, for example, with the biceps muscle, easily felt as a mass of flesh on the front of the forearm (fig. 24). This takes origin from the scapula and is inserted into the radius, the result being that when it contracts, the forearm, being the relatively movable part, is drawn up.

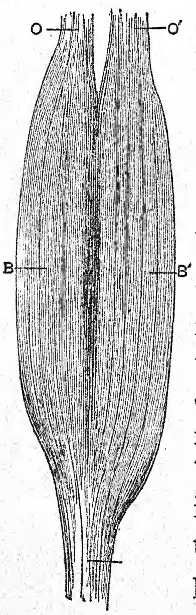


Fig. 24.—Biceps Muscle of the Arm

B B′, Fleshy part; O O′, origin; I, insertion.

Muscles are commonly attached by means of firm fibrous cords, the *tendons*, an arrangement which permits a large number of muscles to be attached to a small part, such as a finger-bone, and further permits such muscles to act from a considerable distance. The use of skeletal parts in giving attachment to muscles is obvious, and the numerous ridges and projections seen on bones are largely related to this function.

Muscle is also important in relation to the movements of

internal organs, as has already been seen in the case of the heart. It also enters into the walls of the blood-vessels, serving to regulate their size, and the walls of the food-tube are also largely composed of the same substance, which here exerts a kind of squeezing action by which the digesting food is gradually passed on. The muscle, however, making up the flesh of the body is different in structure from that found in internal organs, and is termed voluntary, being under the direct control of the will; while the muscle of the heart, &c., is involuntary, because it cannot be regulated in this way.

2. CILIARY ACTION.—Movement in the human body is, however, not all due to muscular action, but can be brought about in two other ways. One of these is *ciliary action*, of which a good example is afforded by the lining of the windpipe. If this is examined under a compound microscope it will be found to be lined with fragments of protoplasm (cells), covered thickly with short protoplasmic threads known as *cilia* (fig. 25). Each cilium is able to alternately bend and straighten itself, and when numerous cilia work together, as is usually the case, they are able to move along small particles placed upon the surface they beset. Their action in the case mentioned is to sweep particles of dust, &c., towards the exterior, thus keeping the ciliated surface clean. The last kind of movement is the peculiar creeping motion exemplified by the colourless corpuscles of blood and lymph (fig. 15). It is said to be *amœboid.*

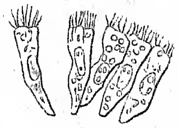


Fig. 25.—Cells of Ciliated Epithelium, much magnified

The two kinds of movement just described are much more primitive than muscular action, and, as might be expected, play a much more leading part in the lower forms of life than they do in such a complicated organism as a human being.

NERVOUS SYSTEM AND SENSE ORGANS.

The great complexity of the body, with its numerous subtly interwoven functions, demands some means of controlling and correlating these, and of keeping the body as a whole in touch with the outer world. The means is found in those organs to which the terms nervous system and sense organs are applied.

THE NERVOUS SYSTEM.—The nervous system essentially consists of certain central organs, which may be regarded as

the head-quarters of the life of the individual; and of numerous branching cords, the *nerves*, which connect up the central organs with all parts of the body. The central organs consist of brain and spinal cord, elaborately sheltered within the axial skeleton (fig. 26), and of a more subsidiary part lodged in the body cavity close against the backbone, and known as the sympathetic nervous system.

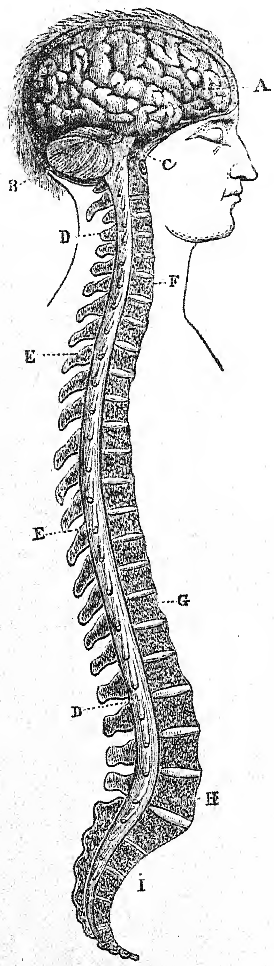


Fig. 26.—Position of Brain and Spinal Cord

A, Right cerebral hemisphere; B, cerebellum; C, upper end of medulla oblongata D D, spinal cord with beginnings of spinal nerves; E E, processes of vertebræ; F G H, last vertebræ of neck, chest, and loin regions; I, sacrum.

The Spinal Cord.—It is best to begin a consideration of these organs with the spinal cord or marrow, a soft cylindrical mass contained in the backbone, and continuous at one end with the brain, while at the other it tapers to a thread. This cord is protected by investing membranes, and in a cross-section (fig. 27) presents a somewhat singular appearance, due to its being made up of two sorts of nervous matter, white and grey, the former being external while the latter constitutes a sort of core, which in the section looks like a couple of cres-

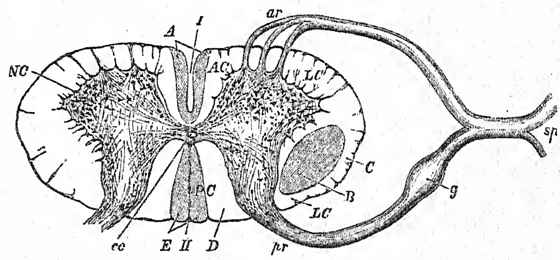


Fig. 27.—Cross section of the Spinal Cord, dorsal side below. Partly diagrammatic. Magnified

N C, Groups of nerve-cells in grey matter; remaining capital letters indicate regions of white matter; *sp*, a spinal nerve, formed by union of dorsal (posterior) and ventral (anterior) roots, *pr* and *ar*; *g*, ganglion on dorsal root.

cents placed back to back. A further point of importance is the presence of a minute central canal, so that the cord can be regarded as a tube with small bore and very thick walls, somewhat as is the case with the stem of a thermo-

meter. The *grey matter* is mainly made up of angular or star-shaped structures of very small size, each of these being a *nerve-* or *ganglion-cell* (fig. 28). It is these cells which collectively make up the essential part of the central organs, while the *white matter* and the nerves consist of an infinite number of slender *nerve-fibres* which have a conducting function. To take an electrical analogy, the nerve-cells may be looked upon as batteries, while the nerve-fibres are comparable to wires. The analogy, however, is a very rough one, for here batteries and wires alike are alive, and there does not appear to be the same coupling up of nerve cells and fibres that exists between batteries and wires in an ordinary electric system. There is indeed a certain amount of connection, but how much is a matter of doubt. Not improbably the cells, to some extent, are able to act independently of fibres, recalling the wireless telegraphy which is now being developed.

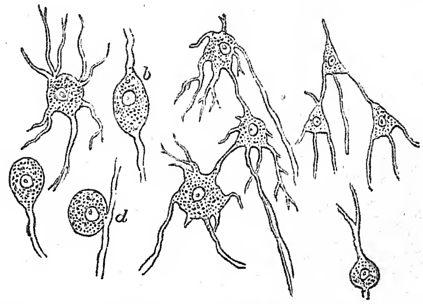


Fig. 28.—Various Forms of Nerve-cells. *b* and *d* from ganglia on dorsal roots of spinal nerves. Observe nucleus in centre of each.

Subject to the brain, a large amount of control over the neck, trunk, and limbs is exerted by the spinal cord, and in accordance with this the parts in question are supplied by numerous pairs of *spinal nerves* which arise from the cord. The examination of any particular spinal nerve (fig. 27) will show that it takes origin in a couple of bundles of fibres which, from their position, are respectively known as the dorsal and ventral roots. It has been shown that, broadly speaking, the fibres of the dorsal root are carrying nerve impulses—telegraphic messages, as it were—to the central organs, while those of the ventral root carry such impulses away from them. To express this, the names afferent and efferent fibres (L. *affĕro*, I carry to; *effĕro*, I carry out) are respectively given. The *afferent fibres* convey information to the central organs about what is going on in the body or outside it, while the *efferent fibres* carry impulses from the central organs to the other parts of the body, with the result that certain actions take place, or it may be that actions in progress are modified or stopped.

The Brain.—The brain is an exceedingly complex organ, and is the centre of sensations and voluntary actions, besides, like the spinal cord, carrying on operations not dependent on the will. It consists of a central axis, which may be regarded as a forward extension of the spinal cord, and of various outgrowths from this. The brains of different kinds of backboned animals differ very largely from one another in the extent to which these outgrowths are developed. In the human brain they attain their largest proportions, and the most noteworthy of them (fig. 26) are the *cerebellum* in the hinder part of the brain, and the two *cerebral hemispheres* in front of these. It is the hemispheres which are of greatest interest, for the grey matter forming their outer layer, or *cortex*, appears to be the ultimate seat of reason, will, and intelligence. It can be mapped out into small areas or centres, which are partly motor, controlling special muscles, and partly sensory, concerned with the special sensations. We have, for example, a special motor area concerned with the muscles of the arm, and if this centre be injured, paralysis of the arm follows. Again, a special centre of vision has been recognized, and if this be damaged, the sight is more or less impaired. In fact, what are termed sensations of sight, hearing, taste, &c., depend on changes taking place in these centres consequent on nerve impulses which are conveyed to the brain along afferent nerve-fibres. The hemispheres are connected together by a broad band of nerve-fibres (corpus callosum), the presence of which is important as regards classification.

The spinal cord is not only a central organ capable of doing certain regulative work on its own account, but also serves as a channel of communication between the brain and those parts of the body supplied by the spinal nerves. The brain, however, communicates directly with the head and some other parts of the body by means of twelve pairs of *cranial nerves* which take origin from it. These differ in many ways from spinal nerves. Some of them are composed entirely of afferent fibres, which place sense organs in communication with the brain, *e.g.* the optic nerve connected with the eye, and the auditory nerve with the internal organs of hearing. Others are entirely composed of efferent fibres, *e.g.* three pairs of small nerves which do nothing but supply the muscles moving the eyeballs. Others, again, contain

both efferent and afferent fibres, as is the case with the remarkable tenth pair of cranial nerves, named vagus on account of their wandering course. Running along the neck, these nerves pass into the thorax, where they send branches to both heart and lungs, and, piercing the midriff, end in branches supplying the stomach.

The Sympathetic System.—This brief survey of the nervous system may be completed by referring to the *sympathetic system*, which consists in the main of a couple of slender cords running ventral to the backbone, and dilating at intervals into small swellings known as the sympathetic ganglia, containing nerve-cells, and therefore considered as collectively constituting a part of the central nervous system. They are connected with the spinal and some of the cranial nerves, and largely control the internal organs and blood-vessels, to which they send numerous branches. The working of the sympathetic system is entirely involuntary, a fortunate circumstance to which we owe the fact that we are very largely unconscious of the internal movements of the body.

SENSE ORGANS.—The sense organs have been described as the implements of the nervous system, gaining, as it does, information about the external world by their means. A sense organ may broadly be regarded as a more or less modified piece of skin adapted to receive impressions from some external agent (contact, heat, light, sound, &c.) or *stimulus* (L. *stimulus*, an ox-goad), and connected up with the central nervous system by a sensory nerve.

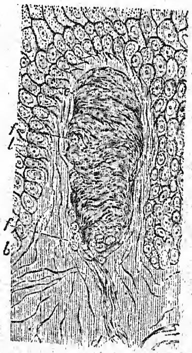


Fig. 29. — Magnified View of a Papilla of Skin, with a Touch Corpuscle

The Skin as a Sense Organ.—The skin of the neck, trunk, and limbs is richly supplied with sensory nerves derived from the spinal cord, while the skin of the head and the linings of the mouth- and nose-cavities receive branches from the fifth cranial nerve. Connected with many of the smallest twigs of these nerves are microscopic bodies which are known as *touch-corpuscles* (fig. 29), because they are believed to have to do with the sense of *touch*. A finger-tip furnishes the best example. Upon it will readily be seen a series of fine ridges arranged in a characteristic manner, differing largely, however, in different individuals, and thus affording an important means of identification. Under these ridges,

imbedded in the deeper layer of the skin (dermis) are to be seen rows of touch-corpuscles. The sense of touch proper gives us information about bodies which actually come into contact with the skin, and how extensive such information may be is seen in the case of blind persons. The sequence of events before we feel a sensation when, say, a finger-tip touches any object, is somewhat as follows:—The first effect of contact is to cause some kind of to-and-fro movement in the minute particles (molecules) of which the touch-corpuscles are made up, or, to use more technical language, a "molecular vibration". The corpuscles may be called the "end-organs of touch", because they form the external end of the set of structures concerned with touch. Next follows a "nerve impulse" (which is another kind of molecular vibration) along the sensory nerve to the spinal cord and thence to the brain. Lastly, a part of the grey matter composing the external coat or cortex of a brain hemisphere is affected, a third variety of molecular vibration being set up in it. Then, and not till then, is a sensation of touch experienced, by which we know that something has happened in the finger-tip. What that something may be is judged by comparison with past happenings of a like nature. The sequence of events here very roughly described for touch applies, *mutatis mutandis*, to any other sense, and therefore will not be spoken of again; but it is important to bear in mind that all the various sensations—touch, taste, smell, hearing, and sight—are, so to speak, manufactured in the brain, and it is only as the result of long practice that we learn to recognize them as resulting from changes set up in end-organs by different external agents (stimuli), enabling us to form judgments about what is happening outside the body altogether.

The skin is not merely concerned with touch proper, but is also the organ of the *temperature-sense*, by which we learn something about the condition of external bodies as regards their condition with reference to heat or cold.

The Sense of Taste (fig. 30).—The object of this sense being to give us information about food, it is not surprising to find its end-organs limited to the lining of the mouth-cavity. The most obvious of these are contained in the mucous membrane of the tongue, upon the upper side of which organ, at the back, are to be noted a number of small projections or *papillæ*, in the sides of

which are imbedded minute ovoid taste-buds containing slender *taste-cells*. These cells are connected with nerve-fibres which have been usually regarded as coming from the ninth cranial nerve, though there is reason to believe that they really belong to the fifth. However that may be, there are only two sensations of taste proper, *i.e.* sweetness and bitterness, and the stimulus which initiates either of these must be something in a dissolved condition. Many so-called tastes are partly smells, and that such "flavours" are of this mixed nature is practically demonstrated by a cold in the head, which largely destroys what we popularly call taste, although only the nose is affected. We are able to smell the food in the mouth by reason of the fact that mouth-cavity and nasal cavities alike communicate with the pharynx (see p. 34). It must also be borne in mind that the lining of the mouth, especially that part of it covering the tongue, also ministers to the sense of touch. The tip of the tongue is even more sensitive in this respect than a finger-tip, and there is also good reason for thinking that what we call "acid tastes" are more properly to be regarded as varieties of touch.

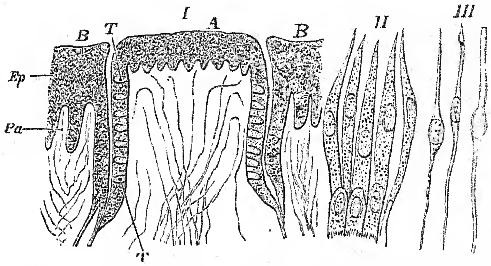


Fig. 30.—Section of Papillæ of the Tongue—highly magnified

I A, Section of the central papilla; B B, section of the surrounding elevation; *Pa*, papilla of the dermis; *Ep*, layer of epithelium; T, taste buds; II and III represent very highly magnified views of cells of the taste buds. Note their oval nuclei.

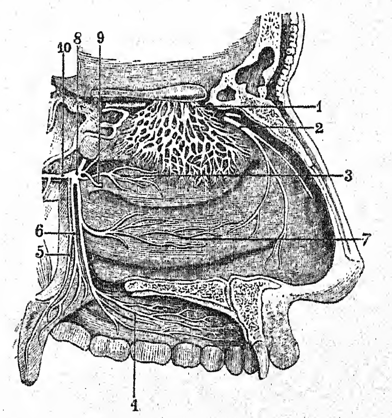


Fig. 31.—Distribution of Nerves over interior of Nasal Cavity, outer wall

1, Branches of nerves of smell—olfactory nerve; 2, nerves of touch to the nostril; 4, 5, 6, nerves to the palate springing from a ganglion at 8; 3, 7, 9, branches from one of the palate nerves to nostrils.

The Sense of Smell (fig. 31).—The organs of smell have to do with testing the quality of the air taken into the lungs, and it is therefore natural that they should be situated at the beginning of the breathing passages. They consist of the two cavities of the nose, opening behind into the pharynx. The mucous membrane which lines the upper part of these cavities contains numerous slender *olfactory cells*, which are the end-organs of

smell, and are acted upon by gases and vapours. Fragrance and its contrary are the only smells to which the name can strictly be applied, as some so-called "odours", such as those of a pungent nature, are due to the delicate sense of touch connected with the nasal cavities. The first cranial or olfactory nerves are those of smell proper, and they supply the end-organs alluded to. As already mentioned, certain sensations which we are accustomed to call tastes are partly of the nature of smells.

The Organs of Hearing (fig. 32).—These complicated structures consist of two subdivisions—(1) the essential parts containing the end-organs, and (2) certain sound-conducting arrangements. (1) The essential parts constituting what is known as the *internal ear* are imbedded in the firm side-wall of the skull, and consist of a complicated bag, the *membranous labyrinth*, on each side. This bag is really a small portion of the skin, which has been folded in so as to reach a sheltered position and escape injury. If the head of an embryo chick be examined, a small pit will be seen on either side of it. This is the commencing internal ear, and later on the mouth of the pit closes, converting it into a minute vesicle lying just below the surface. This vesicle sinks inwards, and gradually assumes the complex shape characteristic of the labyrinth in the adult, while at the same time bony matter is formed round it. The lining of the labyrinth is made up in several places of slender *auditory cells*, which are the end-organs for hearing, and are supplied by the eighth or auditory cranial nerves. (2) The end-organs of hearing are stimulated by those vibrations of the air which are known as sound-waves, but, owing to the deep position of the

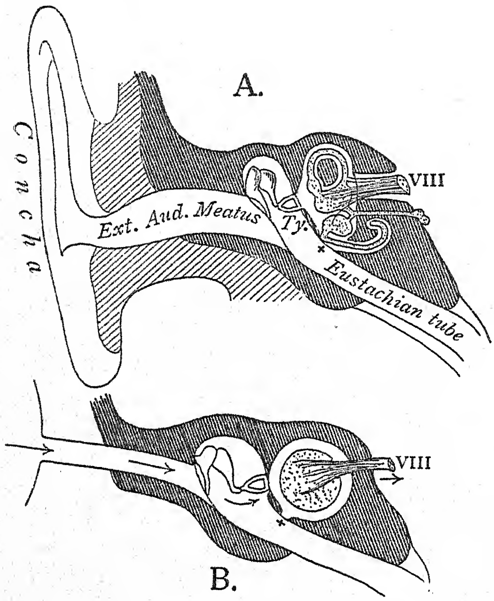


Fig. 32.—Diagrams of Auditory Organs (natural size)

Parts cut through are shaded, the close shading indicating the temporal bone. Membranous labyrinth dotted. *Ty*, Tympanic cavity; VIII, auditory nerve. Arrows indicate direction in which sound-waves and resultant nerve impulses pass. *A* is after Schwalbe, and B is a still simpler diagram.

labyrinth, a special conducting apparatus, consisting of middle and external ears, is necessary. The *external ear* consists of the flap to which the name "ear" is applied in ordinary language, that of *concha* or *pinna* scientifically, and of a short auditory tube leading down into the head. Stretched across the inner end of this tube is a firm tympanic membrane. The *middle ear* consists of a tympanic cavity ("drum" of the ear) internal to the tympanic membrane, and communicating with the pharynx by a tube-like prolongation (Eustachian tube). The internal ear is situated close to the inner side of the tympanic cavity, and at one place the protecting bone is absent, leaving a little oval space, the oval window (fenestra ovalis), filled by membrane only. If this were perforated, the fluid which surrounds the labyrinth would escape into the tympanic cavity. Stretching across the cavity from tympanic membrane to oval window is a chain of minute bones, the auditory ossicles, called, from their shape, hammer, anvil, and stirrup. The handle of the first is fixed to the tympanic membrane, while the foot-plate of the last fits into the oval window. Sound-waves enter the auditory tube, throw the tympanic membrane into vibrations, like those of a drum-head, and this moves the chain of ossicles backwards and forwards, thus acting upon the membrane of the oval window, thereby affecting the fluid surrounding the labyrinth. The wall of the labyrinth itself is thus jolted, and the fluid it contains agitated. So far the vibrations (except the sound-waves themselves) are not molecular, but now begins the first part of hearing proper, for the auditory cells of the labyrinth are thrown into molecular vibration, followed by the transmission of impulses along the auditory nerve to the brain.

The Organs of Sight (fig. 33).—The eyes, which to a very large extent act together, are sheltered in bony depressions of the face known as the orbits, and are provided with muscles for moving them in different directions, which obviously largely adds to their efficiency. There are also other accessory structures, such as eyelids and tear-glands, the former protective, and the latter secreting a fluid which washes the front of the eye, and as it is done with passing down a narrow tube into the nose-cavity.

The eyeball is covered by three coats, of which the outermost, the *sclerotic*, is very tough, and forms what is called "the white" of the eye. A circular external area of this is the transparent

cornea, which permits light rays to enter. Within the sclerotic is a much softer *choroid coat* containing numerous blood-vessels; this, however, does not line the cornea and its immediate neighbourhood, but runs transversely across the front part of the eye to form the coloured part we call the *iris*, in the centre of which is a hole, the *pupil*. Optically speaking the iris is a diaphragm for regulating the amount of light entering the eye, and the size of its central aperture, the pupil, varies in size according to circumstances, becoming very small in a bright light and very large in a dim light. Lining the choroid is a third eye-coat, pulpy in consistency, and known as the *retina*. It contains the end-organs for sight (rods and cones), and acts as a sensitive screen upon which light falls. The second cranial or optic nerves run into the retina, branching within it to supply the rods and cones.

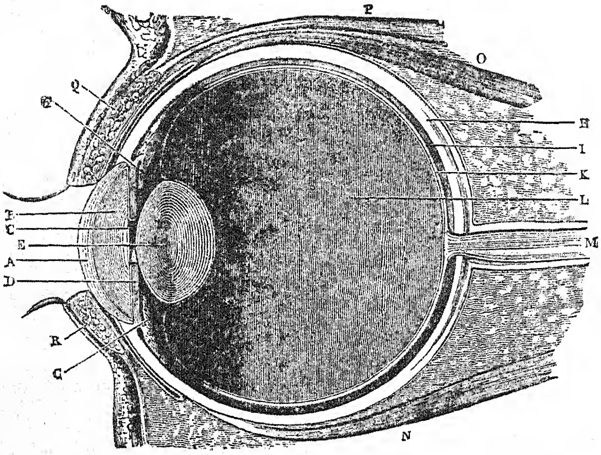


Fig. 33.—Representation of a vertical cut through the Eyeball in its Socket

A, Cornea; B, aqueous humour; C, pupil; D, iris; E, lens; H, sclerotic; I, choroid; K, retina; L, vitreous humour; M, optic nerve; N, an eye-muscle; P, an eyelid-muscle, with an eye-muscle (O) below it; Q R, eyelids.

The eye is filled with refracting structures, of which the most important is the biconvex *lens*, placed just behind the iris. The small space in front of the lens is filled by a clear fluid, the *aqueous humour*, and the much larger space at its back by the jelly-like *vitreous humour*. Just as the lens of a photographer's camera forms a picture of surrounding objects upon the sensitive plate at the back of the apparatus, so do the refracting substances within the eye act with reference to the retina.

A study of the development of the eye shows that its sensitive part, the retina, is formed from an outgrowth of the brain, and as this organ is in reality a piece of skin folded in and much modified, the retina must be looked upon as of the same nature.

Common Origin of Sense Organs.—We have seen that all the sense organs agree with one another in the important point that their essential parts, *i.e.* those containing end-organs, are really modifications of part of the skin, though this is not apparent at first sight, and reference must be made to the facts of development in order to prove it. But as the different sense organs are adapted to respond to very different agents, it is only natural that they should be modified for the purpose, so that the ear, for example, possesses an elaborate sound-conducting apparatus, while the eye consists largely of refracting structures.

CHAPTER II

ESSENTIAL CHARACTERS OF VERTEBRATE ANIMALS. STRUCTURE AND CLASSIFICATION OF MAMMALS

VERTEBRATES AND INVERTEBRATES. — It has already been pointed out (p. 8) that Aristotle in his natural history drew what is perhaps the most important boundary line in zoology, *i.e.* the one dividing Backboned or Vertebrate Animals from Backboneless or Invertebrate ones.

The description which has just been given of the structure and functions of the human body will have given a rough idea of the leading characters of the Vertebrates, and it is now necessary to indicate those features which characterize the group as a whole. The following classes are here included:—

I. MAMMALS, or ordinary warm-blooded quadrupeds.—*Exs.*: Lion, Horse, Rabbit, Bats, Monkeys, Human Beings.
II. BIRDS.—*Exs.*: Fowl, Parrot, Ostrich.
III. REPTILES.—*Exs.*: Crocodiles, Lizards, Turtles, Snakes.
IV. AMPHIBIANS.—*Exs.*: Frogs, Toads, Newts, Salamanders.
V. FISHES.—*Exs.*: Herring, Salmon, Shark, Lamprey.
VI. PROTOCHORDATES, including various low forms, none of which are familiar to most persons.

Essential Characters of Vertebrates. — The body is nearly always bilaterally symmetrical, though cases are known where this is only true for the very young animal while the adult is more or less asymmetrical. A good case in point is that of Flat-fishes, such as turbot, sole, and plaice, in which the young fry closely resemble those of other fish, but as development advances one eye is shifted round to the other side of the head. In a turbot (fig. 34), for example, the dark and light sides are not dorsal and ventral, as might at first sight be supposed, but left and right, both the eyes being situated on the former side, which is kept turned upwards during life.

Segmentation, or division of the body into a number of similar parts or *segments* from before backwards, is another characteristic of Vertebrates, but is not equally obvious in all of them. It is particularly well seen in the lancelet (Amphioxus), a small somewhat fish-like animal classed with the Protochordates (fig. 293).

The body of an average Vertebrate is divisible into *head*, *trunk*, and *tail*, though the last may be entirely absent in some terrestrial forms, as, *e.g.*, the frog, which, however, possesses a large tail in its tadpole stage. When *limbs* are present they are never more than four in number, in which case the fore- and hind-limbs may be much alike, as in a pig, lizard, or newt, or else they may be widely dissimilar, as in a bat or bird, where the fore-limbs are modified for the purposes of flight. One pair of limbs may be entirely absent, as in whales, which possess no hinder extremities, though there can be no doubt that such were present in the ancestral forms from which whales are descended. The complete absence of limbs in certain cases may be due to the fact that they never have been present, as in Protochordates; or it may be a case of the dwindling away and disappearance of members once possessed, as in snakes, which occasionally retain small and imperfect hind-limbs.

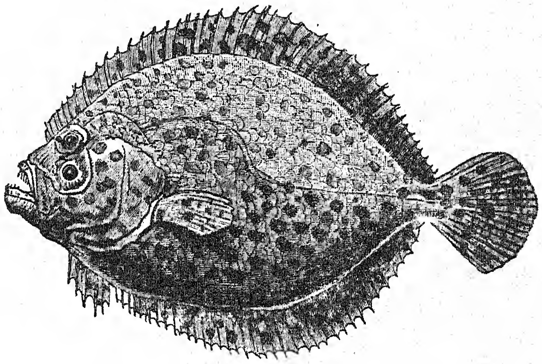


Fig. 34.—Left side (apparent dorsal side) of a Turbot

The *double-tube arrangement*, which has been described as characteristic of the human body, is found among Vertebrates generally, and running along the axis of the trunk between the two tubes is either a backbone proper, or at any rate a firm supporting rod which answers the same purpose. A rod of this sort, the *notochord*, is found throughout life in the lancelet, for example. It is not composed of bone or gristle, but of an elastic substance. Such a rod is found in the embryos of all Vertebrates, but as development proceeds it is usually more or less replaced by a *vertebral column* made of cartilage or bone, or both. The presence of a notochord at some period or other of life is one

of the most distinctive characters of Vertebrates, which for this reason are often termed CHORDATA.

In the vast majority of Vertebrates we find, at the beginning of the digestive tube, *jaws* having an up-and-down movement. Certain of the higher Invertebrates, *e.g.* lobster, scorpion, cockroach, also possess parts which are called jaws, but they are really limbs which move from side to side, are placed entirely outside the mouth, and do not form, as in a Vertebrate, a part of the head.

In all groups of Vertebrates we find that at some period or other of life there are certain slit-like openings on the side of the throat, by means of which the cavity of the pharynx communicates with the exterior (fig. 35). These openings in aquatic forms, such as fishes, become the *gill-slits* of the adult. Probably everyone has lifted up the flap or gill-cover, which is found on each side of the head in such a fish as a salmon or herring, and seen the red comb-like gills attached to the bars between these slits. And those who have not done this are likely to have noticed gold-fish or the like in an aquarium, and if so, will have observed that the animals continually open and shut their mouths, taking in water, which passes out again through these gill-slits in the process of breathing. In such terrestrial forms as Mammals, Reptiles, and Birds such slits are present in the embryo only (fig. 35), but they never perform any function, and ultimately close up altogether, only serving as a token that in the remote past the ancestors of these groups were aquatic forms, possessing gill-slits and breathing by means of gills. Such a statement as the last might appear very far-fetched, were it not that in the life-history of the frog, and other Amphibia, we can actually see a gill-possessing fish-like creature gradually turn before our eyes into a terrestrial animal,

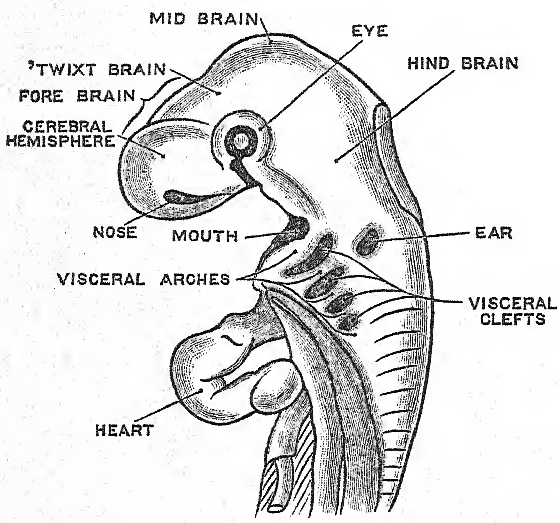


Fig. 35.—Front part of Chick Embryo

breathing air by means of lungs and quite devoid of gills and gill-slits. For it is a familiar commonplace that the frog starts life as a "pollywog" or tadpole, which to all intents and purposes is a fish, and would be classed as such if it developed no further. In due course, however, the tadpole grows lungs, while at the same time its gills shrivel up and its gill-slits close, changes which are accompanied by growth of limbs and loss of tail, the ultimate product of these revolutionary proceedings being a frog.

All Vertebrates possess a *blood system*, consisting of a set of tubes in which blood is circulated, usually by the pumping action of a *heart* placed near the under or ventral side of the animal. In the higher groups the heart is much more complicated in structure than in the lower ones.

The chief part of the *central nervous system* in a Vertebrate is a thick-walled tube, the front part of which is larger than the rest and is termed the *brain*, while the rest is the *spinal cord*. This tube has a dorsal position. The sensitive parts of the characteristic *eyes* are developed as outgrowths of the brain.

A brief survey of the Vertebrate groups, with their subdivisions, may now be appropriately entered into, beginning with the Mammals and ending with the Protochordates.

MAMMALS

Mammals are justly regarded as being the highest group of Backboned animals, and a number of characters mark them off pretty sharply from the remaining groups. These characters, as well as others of less importance, have been for the most part dealt with in the sketch already given of Man, the highest member of the group.

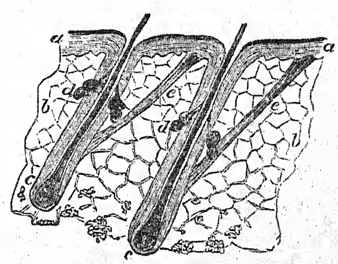


Fig. 36.—Section of Skin, showing Hair, Hair Follicles, and Glands
a, Epidermis; *b*, dermis; *c*, base of hair; *d*, sebaceous glands; *e*, muscle attached to hair follicle.

Probably the two most striking features which characterize a Mammal are the possession of (1) hair and (2) milk-glands, both of which belong to the skin.

(1) *Hair* (fig. 36).—In all cases we find that the epidermis gives rise to a more or less pronounced hairy covering, each hair growing from a deep narrow pit in the skin, called a hair-follicle. Opening into this are two little glands

(sebaceous glands), secreting an oily substance that may be regarded as a sort of natural pomatum. After a hair has attained a certain length it falls out, and is succeeded by another hair growing from the same follicle. Many animals at stated periods of the year undergo a sort of moult in preparation for the growth of a new coat. This is the case, for example, with horses, which lose their hair on the approach of winter and develop a thicker covering.

There is very great variation as to the amount of hair present, some aquatic forms, such as whales, being almost devoid of any such covering, which on the other hand is extraordinarily well developed in such creatures as sheep and goats. There may also be a localization of well-developed hair, as in the mane of horse or lion, and the beard of man and many apes. Not only are there these differences in amount of hair, but also in kind and colour. Both these points are illustrated by the races of mankind, which present such differing types as the fair wavy hair of many Europeans, the black straight hair of the Chinese, and the frizzly wool of negroes. These differences are not merely ones of colour, but shape, for the hairs of a Chinaman are almost perfectly cylindrical, while the wavy hairs are flattened to some extent, and the wool is much flattened, as in curling wood-shavings. In the last case, too, the hairs are set obliquely in the skin. Even in a human being we can distinguish between the coarser hair of the head and the fine downy hair covering most parts of the body; but in many mammals such a distinction is much better marked, as in the fur-seal, which possesses coarse comparatively long hair, together with the soft close-set finer sort which makes the skin valuable commercially. A more violent contrast is seen in a hedgehog (fig. 52), where we find not only ordinary hair, but also spines, which are simply very large strong protective hairs, and this is carried a step further in porcupines.

The epidermis of Mammals also produces other structures, which are more or less allied to hairs. The horn of a rhinoceros is of this nature, and may be considered as a mass of fused hairs, a view which is confirmed by examination of sections under the microscope. The fringed scales of some armadilloes are to be looked upon in a similar light, while such structures as claws, nails, and the hollow horns of cattle are more remotely related.

Mammals exhibit the greatest variety in the *coloration* of the hairy covering of the body, and some of the colour-schemes

are of great beauty, as, for example, in tigers and leopards. As a general rule, the under side of the body is paler than the rest (see p. 22). In the inhabitants of cold climates it frequently happens that there is a well-marked distinction between summer and winter coats in the matter of colour. All these different arrangements are not haphazard, but bear a definite relation to the habits of the animal, commonly rendering them inconspicuous to foes or prey, &c. Such uses will be fully dealt with elsewhere, when the colours of animals in general will be considered.

(2) *Milk*.—One of the most noteworthy features regarding Mammals is the care taken by them of their young, a character which has much to do with the dominant position in the struggle for existence which has been gained by this group of animals. The word "gained" is used advisedly, for geological study shows us that this leading place was in earlier periods occupied by types of very different kind; *e.g.* the Reptiles constituted what may be called the last reigning Vertebrate dynasty prior to the Age of Mammals in which we now live. Just as in that age Man, the newest comer, has, in virtue of his intellectual qualities, dethroned his lower relatives and taken first place.

It is a matter of common knowledge that in the early part of their existence the young of Mammals are nourished by milk, a substance which also plays, in various forms, a most important part in the economy of human adults. As might be expected, milk is an exceedingly nutritious substance, and may be taken as the type of a perfect food. The composition of cow's milk is approximately as follows:—

Water, ...		87·0
Solids, consisting of—		
1. Albuminoids (chiefly casein), ...	4·0	
2. Carbohydrates (milk-sugar), ...	4·6	
3. Fats, ...	3·7	
4. Inorganic salts, ...	0·7	
		13·0
		100·0

It will be seen (see p. 33) that all the necessary constituents of animal food are present, and it may be added that they are in the most advantageous proportions.

A Mammal possesses one or more pairs of *milk-glands*, and their position varies considerably in different species, but in all

cases such a gland consists of an aggregate of blindly-ending tubes which are ingrowths of the epidermis. As a general rule, these tubes open externally upon a *teat*, but in the two lowest known Mammals this is not the case, there being a simple depression of the skin, within which milk-pores are seen.

Besides the two important characters just dealt with, the Mammalia are distinguished by others of scarcely less value, which may be conveniently dealt with under the headings employed when describing the anatomy of the human subject.

Endoskeleton (see pp. 25–32).—Two very noteworthy features enable one to distinguish the *skull* of a Mammal from that of other Vertebrates. One is the presence of two occipital condyles at the back, and the other is the fact that the lower jaw is made up of only two pieces united together in front. Birds and Reptiles possess only one such condyle, and this, in cases where a well-developed neck is present, allows the head a very free motion, as may be observed in a bird, though in this particular case the large range of movement is also in part due to the existence of very perfect joints in the neck itself. Amphibia, *e.g.* the frog, also have two occipital condyles, but their skulls differ from those of Mammalia in so many other ways that no one is likely to be led into error thereby. As to the nature of the lower jaw, it is made up of a considerable number of pieces in Vertebrates lower than Mammals.

The *backbone* of a Man is typically Mammalian in its main features, except that the tail region is much more reduced than is usually the case. We note that the individual joints are flat-ended, and that in the young state the body or centrum of each is made up of a central piece, to which a bony disc is united at each end. This character applies to all but the very lowest members of the group. A further typical feature, to which but very few exceptions are known, is found in the fact that the vertebræ of the neck are seven in number, even in a giraffe.

The skeleton of the human *limbs* is typical in many ways, the chief modifications of a special nature being seen in the structure of the lower limbs, especially as regards the peculiar arches of the pelvis. Such peculiarities are adaptations to the requirements of the erect attitude. But the various bones recognizable in Man are recognizable also in most Mammals, and it may in particular be remarked that the possession of five fingers and five toes is the

typical condition, though all sorts of reductions in number may take place, by which a fitness for special kinds of locomotion, &c., is brought about. The most extreme case is that of the horse, which possesses but one well-developed digit in each limb.

Digestive Organs (see pp. 34–38).—In most respects the digestive organs of Man may be taken as typical, especially as regards the fact that there are two sets of teeth, and that these teeth are of several kinds. The total of thirty-two for the permanent set is not, however, typical, a much nearer approach to this being found in the pig, which possesses forty-four teeth in all, arranged according to the following dental formula:—

$$i.=\frac{3-3}{3-3},\quad c.=\frac{1-1}{1-1},\quad p.m.=\frac{4-4}{4-4},\quad m.=\frac{3-3}{3-3}=44.$$

Many Mammals, however, have undergone much greater reduction in the number of teeth than human beings, and in some species these structures have been lost altogether, as in the Great Ant-eater of South America. Porpoises and the like, on the other hand, have a very large number of teeth not divided into distinct kinds. The nature of the teeth, which is determined by the kind of food, is of great classificatory importance.

Circulatory Organs (see pp. 38–43).—Hot blood (about 98° F.), a four-chambered heart, with impure blood on its right and pure blood on its left side, and an aorta with its arch curving to the left, are the most characteristic features, and have all been dealt with in the preliminary sketch.

The necessity of maintaining the blood at a temperature often higher than that of the surrounding medium appears to be one reason for the possession of a thick coating of hair.

Respiratory Organs (see pp. 45–47).—No Mammal at any time possesses gills, though gill-slits are found in the embryo (see p. 62), but breathing is always effected by a pair of spongy *lungs* situated in the cavity of the thorax. There is present, as in Man, a partly muscular partition, the midriff or *diaphragm*, separating the cavity of the thorax from that of the abdomen, and materially assisting in the movements of breathing by which the air in the lungs is renewed.

Nervous System (see pp. 49–53).—The arrangements described in Man may be taken as fairly typical for Mammals in general, except as regards the *brain*, which is proportionately very much larger than in any other form.

It is characteristic that the cerebral hemispheres should be large, and united by a corpus callosum, while their surface is usually marked by more or less distinct convolutions. There is a relation between the intelligence of a Mammal and the size and complexity as regards convolutions of its hemispheres.

CLASSIFICATION OF MAMMALS

Existing Mammals fall into three natural groups, which are again subdivided into Orders, the arrangement being as follows:—

A. Eutheria.—This group embraces the vast majority of Mammals, including all the highest forms and those with which we are most familiar in this country. The distinctive characters mostly require a specialist knowledge of anatomy to be appreciated, and it may suffice to state that the hemispheres of the brain are large and convoluted, and that the young are born in a comparatively perfect condition, never being sheltered in a pouch after birth, as is the case with the second group of Mammals.

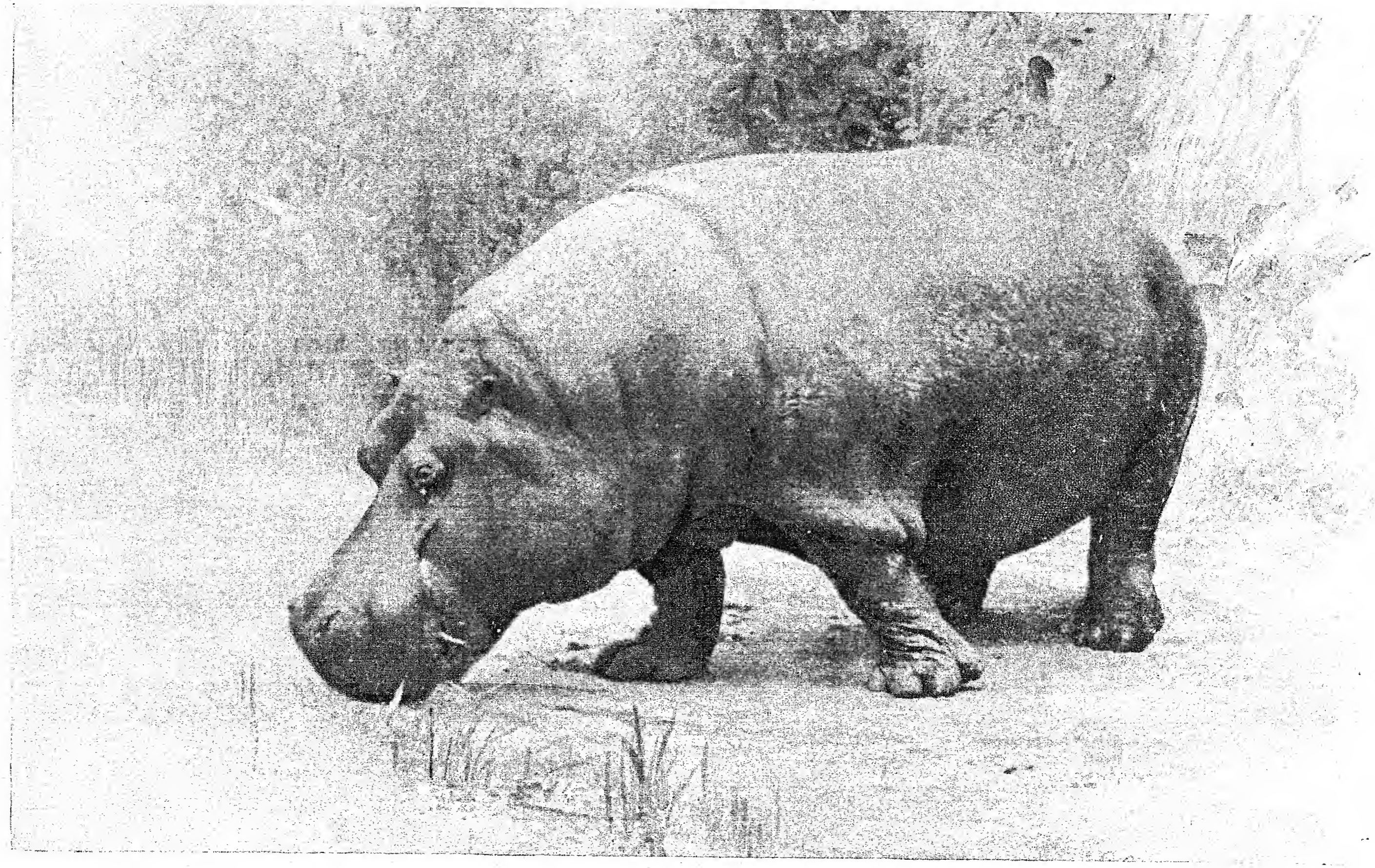
The orders are as follows:—

1. *Primates.—Exs.*: Man, Apes, Monkeys.
2. *Lemurs* (Lemuroidea).
3. *Bats* (Chiroptera).
4. *Insect-eaters* (Insectivora).—*Exs.*: Hedgehog, Mole, Shrew.
5. *Flesh-eaters* (Carnivora).—*Exs.*: Dog, Cat, Bear, Otter, Seal.
6. *Cetacea.—Exs.*: Whale, Porpoise.
7. *Sea-cows* (Sirenia).—*Exs.*: Dugong, Manatee.
8. *Elephants* (Proboscidea).
9. *Conies* (Hyracoidea).—*Ex.*: Syrian Hyrax.
10. *Hoofed Mammals* (Ungulata).—*Exs.*: Tapir, Rhinoceros, Horse, Hippopotamus, Pig, Deer, Cattle, Giraffe, Camel.
11. *Gnawers* (Rodentia).—*Exs.*: Squirrel, Rat, Porcupine, Rabbit.
12. *Edentates* (Edentata).—*Exs.*: Sloth, Armadillo, Ant-Eater, Pangolin.

B. Metatheria.—The forms embraced by this group have smooth and relatively small cerebral hemispheres. The young are born in a very immature condition, and are usually sheltered for a time in a pouch ventral to the abdominal region of the mother. Within this pouch are situated the long teats, to which the young remain attached for some time, and these are so immature as to be at first incapable of sucking, the milk being squeezed into their mouths. Under such conditions they would be in imminent danger of choking were it not that the top of the

THE HIPPOPOTAMUS (*Hippopotamus amphibius*)

The Hippopotamus is closely related to the members of the Pig family, and, like them, does not chew the cud. It lives for the most part in water, inhabiting some of the great African rivers. A closely allied species inhabited Britain during prehistoric times. The Hippopotamus is a remarkably bulky animal, and weighs from three to four tons when adult.



THE HIPPOPOTAMUS (HIPPOPOTAMUS AMPHIBIUS)

A STUDY FROM THE LIFE

windpipe projects into the back of the nasal passages, so that the feeding and breathing tracts are kept separate.

There are also two well-marked features of the skeleton, one concerning the lower jaw and the other the pelvis. The hinder corners or angles of the former are bent (inflected) inwards (fig. 37), while the latter possesses two extra bones (epipubic bones) which are at most represented by vestiges in members of the Eutheria.

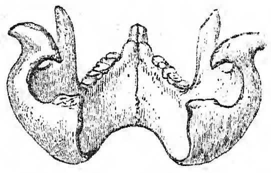


Fig. 37.—Lower Jaw of a Wombat from behind. Note inwardly bent angles.

There is only one order, *i.e.*:

13. *Pouched Mammals* (Marsupials), of which all the existing types are limited to Australia and its adjacent islands, with a few exceptions found in America.—*Exs.*: Kangaroo, Wombat, American Opossums.

C. PROTOTHERIA.—A very small number of Mammals constitute this group, and they are marked off from the higher forms by the possession of very remarkable characters. Agreeing with Marsupials in the characters of the brain, which is, however, of a still lower type, and the presence of epipubic bones, they differ from them and all other Mammals in the fact that they lay tough-shelled eggs. The young, when hatched, are nourished by milk, as in other cases, but the milk-glands possess no teats, simply opening upon a bare patch of skin. The Prototheria are also distinguished by the comparatively low temperature of the blood, the peculiar structure of the shoulder-girdles, and the fact that the intestine ends by opening into a chamber, the *cloaca*, which also receives the products of nitrogenous waste. As to the shoulder-girdle, it was mentioned in describing the human scapula (p. 30) that a coracoid process is present on that bone, and that the process in question must be regarded as the vestige of what in ancestral forms was a distinct bone. Prototheria possess a distinct coracoid bone (fig. 38), and also certain other bony elements in the shoulder-girdle, approximating in this respect to what is found in lizards among the Reptiles. It may indeed be noted generally that the peculiar characteristics of these lowest Mammals point to reptilian affinities.

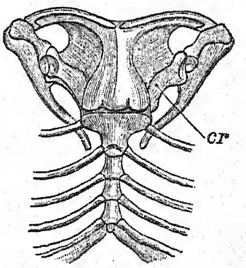


Fig. 38.—Sternum and Shoulder-girdles of Duck-Mole, from below *cr*, Coracoid bone, just above which is the cup (glenoid cavity) for attachment of upper-arm bone.

There is only one order of Prototheria, *i.e.*:

14. *Monotremes* (Monotremata), including only three living genera—the Duck-Mole (*Ornithorhynchus*), found in Australia and Tasmania (fig. 39); the Spiny Ant-Eater (*Echidna*) of Australia, Tasmania, and New Guinea; and the Spiny-tongued Ant-Eater (*Proechidna*), limited to the last-named island.

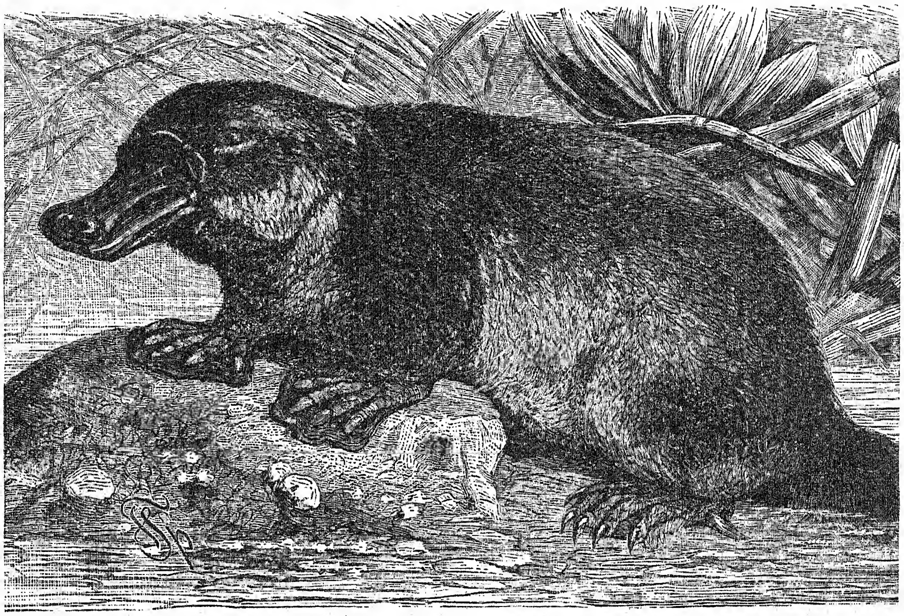


Fig. 39.—Duck-billed Platypus or Duck-Mole (*Ornithorhynchus paradoxus*).

Order I.—Man and Monkeys (Primates)

I. *Man.*—Human beings are distinguished from all other Primates by the possession of vastly superior mental powers, but when structural features are regarded there is no marked difference, and every organ found in a man exists equally in an ape. The human brain, however, in correlation with the human intellect, is very much larger than that of any ape, and the convolutions of its hemispheres are much more complex. This is true for the lowest savage equally with the genius. Man, again, is the only Mammal to which the erect posture is easy and habitual, and we accordingly find that the lower limbs are specially modified with a view to the maintenance of this position. And as compared with the highest apes, the human upper limbs are comparatively short, and adapted to perform the most delicate manipulations.

Although the differences between the different races of mankind are well marked, all are now regarded as having sprung from a common stock, and as belonging to the same genus, Homo, and the same species, sapiens. The scientific name for Man, regarded as an animal, is therefore *Homo sapiens*.

II. *Apes and Monkeys*.—These are tropical mammals closely approximating to Man in structure, with opposable thumbs, eyes

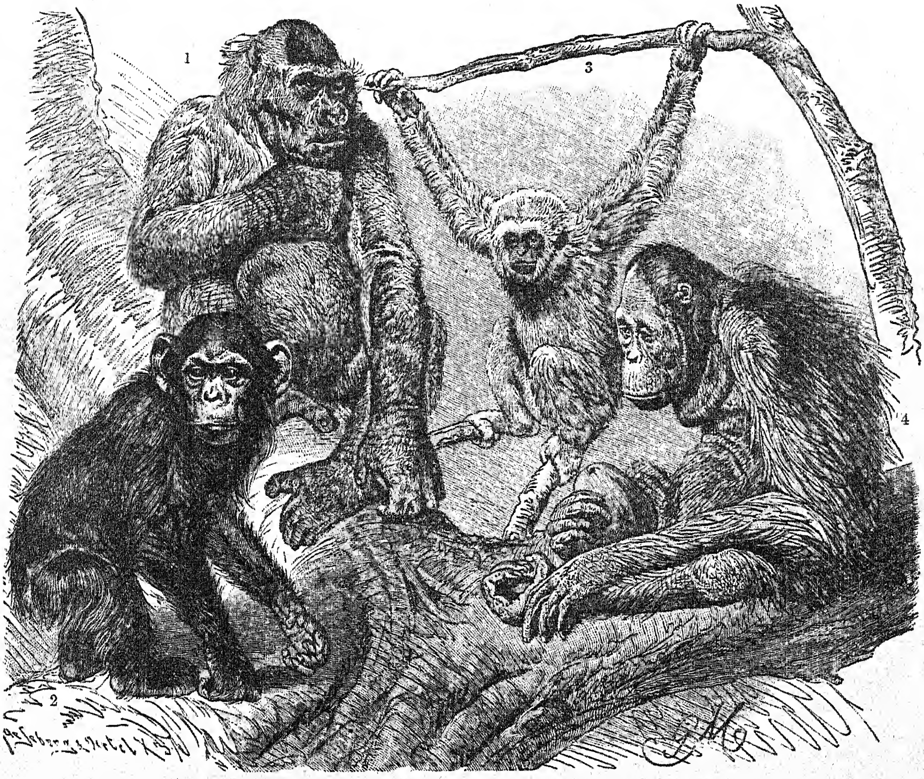


Fig. 40.—Anthropoid Apes

1, Gorilla (*Gorilla Savagei*); 2, Chimpanzee (*Anthropopithecus niger*); 3, Silver Gibbon (*Hylobates leuciscus*); 4, Orang-utan (*Simia satyrus*).

placed in orbits which are complete bony cups, teeth of the four typical kinds, and agreeing pretty closely in number with those of Man, and a pair of milk-glands situated on the chest. A point, related to the habit of climbing, in which these animals differ from Man, is found in the possession of opposable great toes.

Monkeys may be divided into three groups, corresponding largely to their geographical distribution: (1) Old World Monkeys, (2) New World Monkeys, and (3) Marmosets.

(1) *Old World Monkeys.*—These agree with Man in the number of the teeth, so that the dental formula is the same. They do not possess a well-formed projecting nose, but the nostrils are forwardly directed and close together, being separated by a narrow partition.

The *man-like* or *anthropoid apes* (fig. 40), come nearest to Man in structure. They include the Gorilla and Chimpanzee,

Fig. 41.—Entellus Monkeys (*Semnopithecus entellus*).

which are limited to the dense tropical forests of West and Central Africa, the Orang-utan, of Borneo and Sumatra, and the Gibbons of the East Indian Islands, further India, and South China.

The *tailed monkeys* constitute the remainder of the Old World section of ape-like forms. They are provided with hard patches (callosities) on the hind-quarters, and many of them possess cheek-pouches in which, as known to all visitors of zoological gardens and menageries, food can be temporarily stored.

Of these tailed monkeys, one group includes tree-inhabiting forms of comparatively slight build, a good example of which is the Entellus Monkey, or Hunuman (*Semnopithecus entellus*)

(fig. 41). It is held sacred by the natives of India, and is therefore allowed to commit serious depredations without let or hindrance. Another species of the same genus (*S. roxellanus*), found in the north of Thibet, has a well-developed pug nose; and in a Bornean form, the Proboscis Monkey (*S. nasica*), that

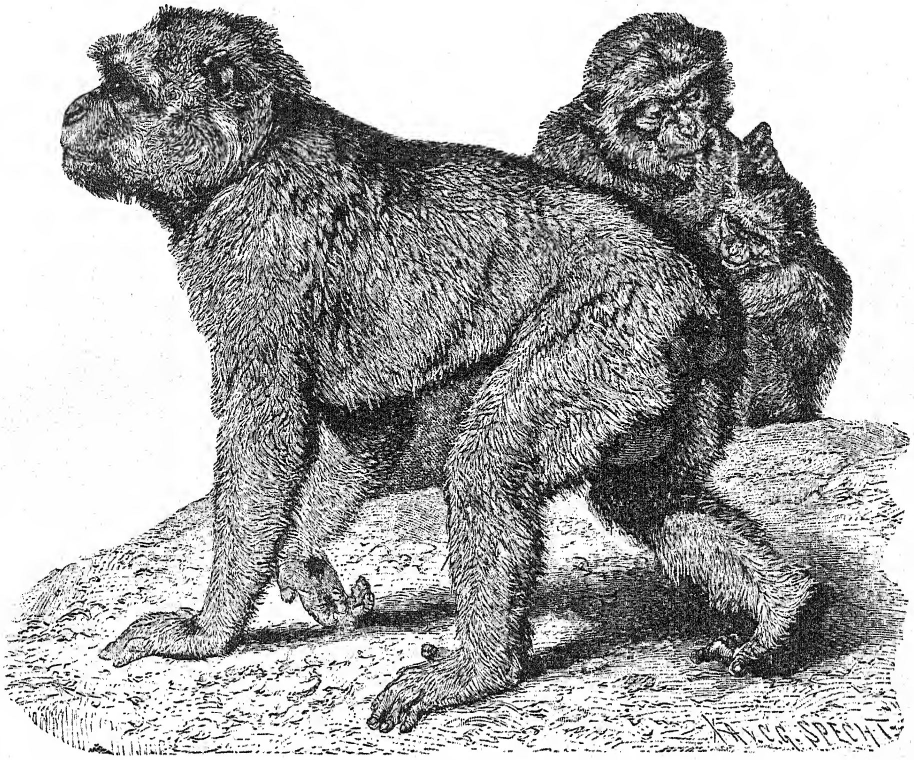


Fig. 42.—The Barbary Ape (*Inuus ecaudatus*).

part of the anatomy has a more classic outline, and confers upon the animal an expression of comic wisdom.

The *Colobi* of tropical Africa are comparable to the members of the preceding genus, from which they are distinguished by stronger jaws and a greatly reduced condition of the thumb. A typical species is the Guereza (*Colobus guereza*), of the Abyssinian highlands.

The *Guenons* are representatives of another African genus (*Cercopithecus*) closely related to Semnopithecus, but differing in the possession of cheek-pouches, and a relatively large thumb. The members of the different species live together in large communities, and on account of their thievish habits are regarded

with far from friendly feelings by the natives. One of the prettiest species is the West African Diana Monkey (*Cercopithecus diana*), in which the face is surrounded by a quaint-looking border of white fur drawn out below into a pointed beard. Another example is the Green Guenon (*C. sabæus*), which is among the common inhabitants of the monkey-house at the Zoo. The Moustache Monkey (*C. cephus*) is a handsome species of the same genus.

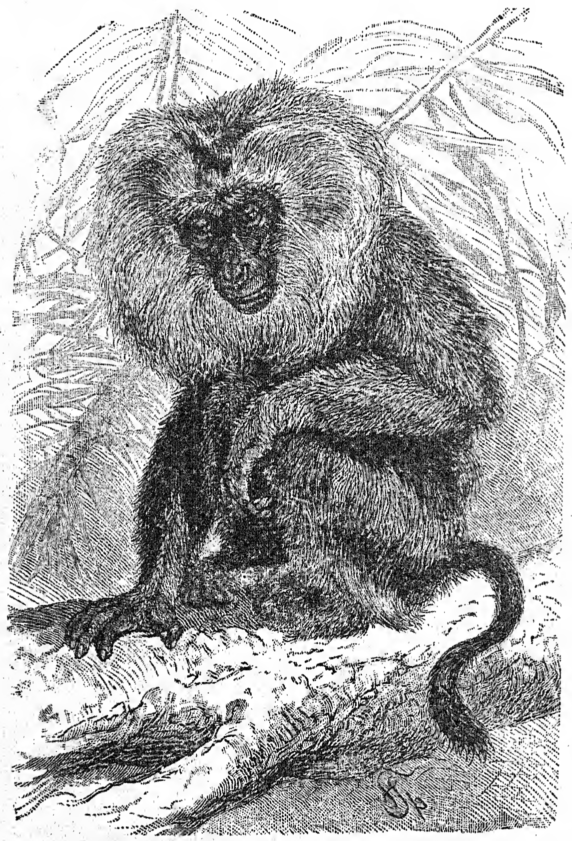


Fig. 43.—The Wanderoo (*Macacus silenus*).

Macaques, belonging to the genus *Macacus*, are of stouter build than the preceding species, and their tails at most do not exceed the body in length. Cheek-pouches are present. One species, the Magot, or Barbary Ape (*Macacus* or *Inuus ecaudatus*) (fig. 42), is of special interest, as being the only monkey with a range extending into Europe; for though its head-quarters are to be found in North Africa, it also occurs on the rock of Gibraltar, an interesting fact of distribution which has led to the popular belief that there is a submarine passage between Africa and Europe. The Boonder, or Rhesus Monkey (*Macacus rhesus*) of the East Indies, which is particularly common in the basin of the Ganges, has the same reverence extended to it by the natives as in the case of the Hunuman. Very similar in character is the Java Monkey (*M. cynomolgus*), but the Wanderoo (*M. silenus*) of Malabar is much more like a baboon (fig. 43). It is endowed with white beard and whiskers of ample proportions, and, being

the happy possessor of a wide range of mental characteristics, has been variously described as "a comedian" and "the philosopher among the monkeys". It should be noted that all the Macaques, with the exception of the Barbary Ape, are Asiatic forms.

The familiar *Baboons*, which live chiefly on the ground and have dog-like heads, are for the most part natives of Africa.

Fig. 44.—The Mandrill (*Papio mormon*)

The Arabian Baboon (*Papio hamadryas*), which once lived in Egypt also, was the prototype of Thoth, the old Egyptian God of Letters, and in this capacity, as well as in the humbler one of a simple ape, is often represented upon the ancient monuments of that country. It is a large and powerful creature of greyish colour, and the adult male, with his pinkish face, large mane on neck and shoulders, and bright-red swellings of large size on the hind-quarters, is by no means a prepossessing object. The West African Mandrill (*Papio mormon*) (fig. 44), however, is even more hideous. Its adornments are of a vivid nature, for there are blue

swellings on the face, and the large bare projections on the hinder regions are blue and red. The Yellow Baboon (*Papio babuin*) of West Africa is handsome by comparison with the two last species.

(2) *New World Monkeys* are a stage lower in development than those of the Old World, and consequently less human in appearance and structure. They always possess a tail, which is commonly used as a grasping organ, and may also serve as

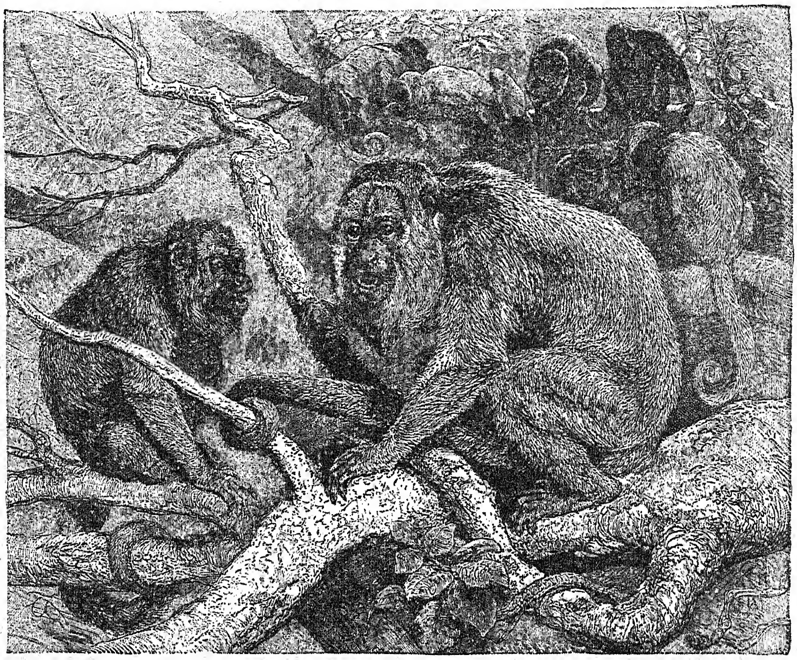


Fig. 45.—Red Howling Monkeys (*Mycetes seniculus*)

a delicate organ of touch. The total number of permanent teeth is thirty-six, four more than in Man and the Old World apes, the excess being due to the presence of an extra premolar on each side of each jaw. There is also a difference in the nose, which has nostrils facing somewhat sideways, and separated by a broad partition.

Three distinct sections are recognized:—Naked-tailed Monkeys, Sajous, and Sakis.

In the *Naked-tailed Monkeys*, at least part of the long and powerful tail is devoid of hair on the under side, and is used as a tactile and grasping organ. Among the noisiest of these forms are the *Howlers* of South America, such, for example, as the Red Howler (*Mycetes seniculus*) (fig. 45), in which the vocal organs are

provided with peculiar resonating structures that greatly add to the volume of sound produced in the dismal concerts to which these animals are addicted. Other illustrative species are the Barrigudo (*Lagothrix Humboldti*), with woolly fur, and the slender *Spider-*

Fig. 46.—The Miriki or Woolly Spider-Monkey (*Eriodes arachnoides*)

Monkeys, such as the Miriki (*Eriodes arachnoides*) (fig. 46), which are distinguished by the reduced condition of the thumb.

The most familiar New World monkeys are probably the *Sajous* or *Capuchin Monkeys*, belonging to the genus *Cebus*. The face is bare and wrinkled, and there are generally peculiar adornments of the nature of whiskers, &c. The long prehensile tail is completely covered with hair, and does not serve as an organ of touch. An example is the Weeper Capuchin (*Cebus capucinus*).

Lastly, in the *Sakis* the tail is not modified as a grasping organ. Examples are the Black Saki (*Pithecia Satanas*), with bushy tail and ample beard, found in the basins of the Orinoco and Amazons, and the Squirrel Monkey (*Chrysothrix sciurea*) of Guiana.

(3) The *Marmosets* or *Clawed Monkeys* of America are the lowest and least intelligent forms to which the name "monkey"

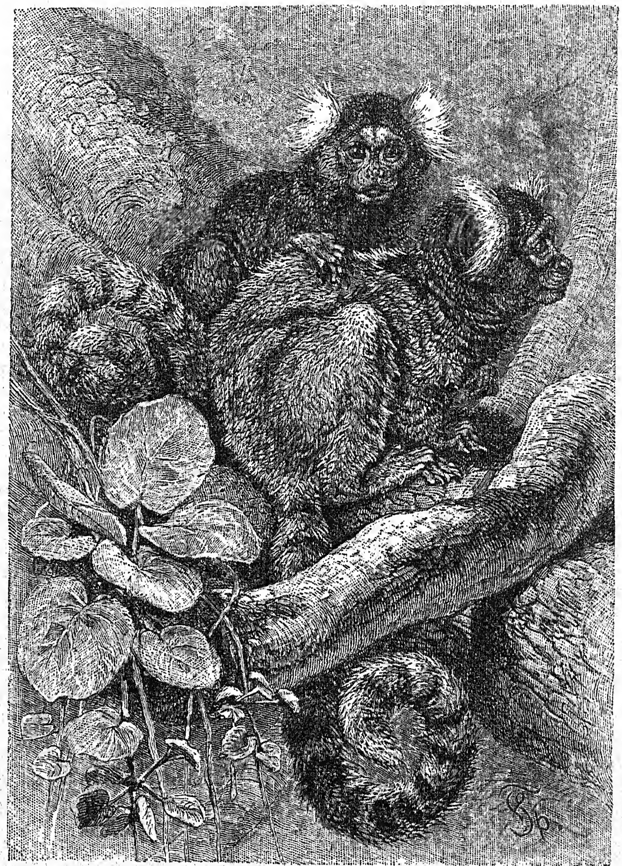


Fig. 47.—The Ouistiti or Common Marmoset (*Hapale Jacchus*)

can properly be applied. These small creatures, of which the Common Marmoset (*Hapale Jacchus*) may be taken as type (fig. 47), have claws on all the digits except the great toe, which is provided with a flat tail, and is opposable. The thumb, unlike that of an ordinary monkey, is non-opposable. The teeth are thirty-two in number, as in Man and the Old World forms, but the dental formula is different, for whereas these possess eight

premolars and twelve molars, a Marmoset has twelve premolars and eight molars, agreeing in the former particular with the New World monkeys proper.

Order 2.—Lemurs (Lemuroidea)

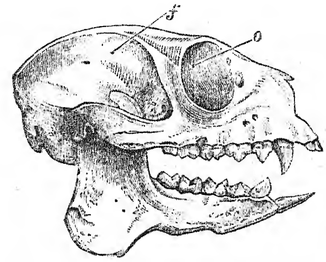


Fig. 48.—Skull of Black Indris Lemur

f, Temporal fossa; *o*, orbit. In this case the orbit is open behind and thus communicates with the temporal fossa.

This order includes a somewhat heterogeneous collection of tropical climbing mammals, of which the large majority are limited to Madagascar, while a smaller number are found in South-east Asia and in tropical West Africa. They have usually been included in the Primates, but on insufficient grounds, the chief common peculiarity being the possession of opposable thumb

Fig. 49.—Ring-tailed Lemur (*Lemur catta*)

and great toe, a character associated with the climbing habit. The brain-case is relatively smaller than in a monkey, and the orbits are not completely walled in at the back by bone (fig. 48). In accordance with their nocturnal habits these animals have

Fig. 50.—The Spectre-Tarsier (*Tarsius spectrum*)

large and sometimes even enormous eyes. There are generally more than one pair of mammary glands.

The Ring-tailed Lemur (*Lemur catta*) of South-west Madagascar may be taken as an average member of the order (fig. 49), while the little Spectre-Tarsier (*Tarsius spectrum*), with a body of only about 6 inches long, will serve as an example of the forms with especially large eyes (fig. 50). It is an East Indian and Philippine species.

Order 3.—Bats (Chiroptera)

Bats or "flittermice" differ from all other mammals in the possession of efficient flying-organs, differing entirely in structure, however, from the wings of a bird. A tough membrane extends between the body, limbs, and commonly the tail as well (fig 51). The thumb is free, or partly so, and is provided with a strong curved claw, but the fingers are exceedingly long and slender, their use being to keep the membrane extended, thus

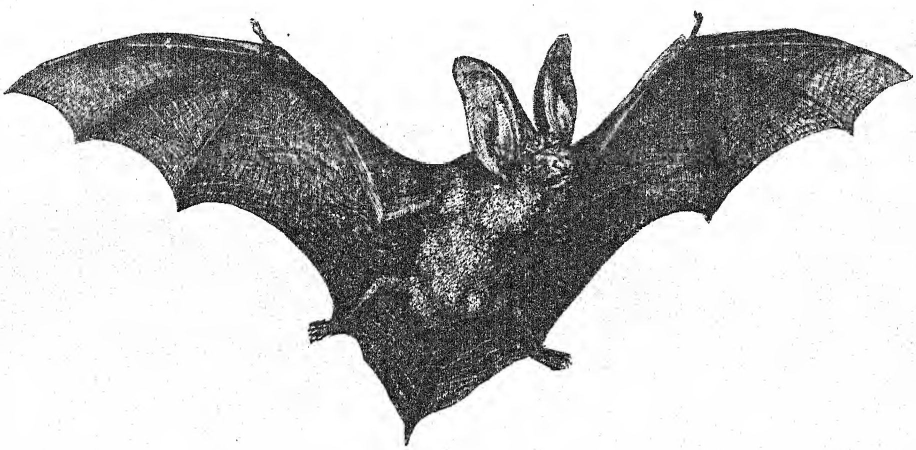


Fig. 51.—The Long-eared Bat (*Plecotus auritus*)

acting pretty much like the ribs of an umbrella. Bats, though nocturnal, have very small eyes, whence the expression "blind as a bat", but this is compensated by their long sensitive ears, and in many cases there are also curious leaf-like outgrowths on the nose. All our native bats, like the majority of forms included in the order, live on insects, and in accordance with this habit have numerous sharply-pointed teeth. A pair of mammary glands are present, situated on the breast. Although the general appearance of a bat's body enables us to understand why it should have received the old English name of flitter-*mouse*, these animals are in reality much more closely allied to hedgehogs and moles.

The order is divided into the two sections of Fruit-eating Bats and Insect-eating Bats.

The comparatively small section of *Fruit-eating Bats* only

includes the so-called Flying-foxes, which are natives of the Old World, Australia, and the South Sea Islands. The cheek-teeth have flattened crowns adapted for chewing, and there is generally a claw on the first finger as well as on the thumb. A typical species is the Kalong (*Pteropus edulis*) of the East Indies.

The *Insect-eating Bats* are by far the larger section, and include all our undoubted native species, twelve in number. All the cheek-teeth have sharp-pointed crowns, there is a claw on the thumb only, and the snout is shorter than in the fruit-eating forms. There are two families:—The True Bats (Vespertilionidæ) and the Leaf-nosed Bats (Phyllostomata).

In the *True Bats* (Vespertilionidæ), which are cosmopolite, the nose is simple in form, but there is a sensitive pointed projection from inside the ear to which the name of "earlet" (tragus) has been given.

A common British kind is the Long-eared Bat (*Plecotus auritus*) (fig. 51), abundant in the wooded regions of Europe, and ranging as far as India.

The European kinds which possess the greatest powers of flight belong to the genus *Vesperugo*, and include the Noctule (*V. noctula*) and the Pipistrelle (*V. pipistrellus*), which are respectively the largest and smallest of our native species.[1]

The *Leaf-nosed Bats* (Phyllostomata) are for the most part natives of the tropics, and differ from the preceding family in the possession of outgrowths from the nose, which serve apparently as special organs of touch. The food is not limited to insects, but may also include fruit, and some of them attack birds and mammals of other groups. A comparatively small and simple nose-leaf is found in the cave-inhabiting form to which reference is frequently made in works on Egyptian exploration (*Rhinopoma microphyllum*). A larger nose-leaf is present in the South American *Vampires*, which have earned an unenviable notoriety on account of their blood-sucking propensities, though an enormous grain of salt must be added to the numerous legends and stories which are current. The largest species is the True Vampire (*Phyllostoma spectrum*), which with its sharp front teeth is able to inflict a small wound

[1] The remaining British members of the family, omitting doubtful cases, are:—Hairy-armed Bat (*Vesperugo Leisleri*), Serotine Bat (*V. serotinus*), Bechstein's Bat (*Vespertilio Bechsteini*), Natterer's Bat (*V. Nattereri*), Daubentin's Bat (*V. Daubentini*), Whiskered Bat (*V. mystacinus*), and the Barbastelle (*Synotus barbastellus*).

in the body of a sleeping animal, the toes being the region favoured in the case of human beings. It is, however, only fair to add, that insects, or even fruit, are the favourite articles of diet.

A very complicated nose-leaf is found in the Old World forms belonging to the genus Rhinolophus, which are known as *Horse-shoe Bats*. Though these range from England to Tasmania, their head-quarters are in the southern parts of Asia. Only two forms, both of which occur in Britain, are found in Europe north of the Alps. These are the Lesser Horse-shoe Bat (*Rhinolophus hipposideros*) and the Greater Horse-shoe Bat (*R. ferrumequinum*).

Order 4.—Insect-Eaters (Insectivora)

Insectivores (fig. 52) are small nocturnal mammals of low organization, adapted for preying upon insects, worms, snails, and other small creatures, for the seizing and holding of which their sharp-pointed teeth are peculiarly well adapted. There is generally a long pointed snout, suited for poking into the small corners and crevices inhabited by their prey. As might be expected in a primitive group like this, there are the typical number of digits, *i.e.* five on each hand and foot, and all are provided with claws. Several pairs of mammary glands are found in the abdominal region. Six groups of the Insectivora may be distinguished:—Banxrings, Jumping-Shrews, Desmans, Shrews, Hedgehogs, and Moles.

Banxrings or *Tree-Shrews* are arboreal forms which somewhat resemble squirrels in appearance, chiefly owing to the presence of a large bushy tail; but the long pointed snout is characteristically insectivore. A typical form is the Bornean Tree-Shrew (*Tupaia tana*).

The African group of *Jumping-Shrews* includes small long-snouted creatures common in desert regions, and distinguished by the relative length of their hind-limbs, upon which they spring actively about. The Elephant-Shrew (*Macroscelides typicus*) of South Africa is a good example.

Desmans are swimming forms found in Thibet, West Africa, South Russia, and North Spain. One of the best-known species is the Musk-Shrew (*Myogale moschata*) of the Volga and other Russian rivers.

All the preceding are small groups, but the mouse-like *Shrews* include a large number of species, and are found in all parts of the world except South America and Australia with its related

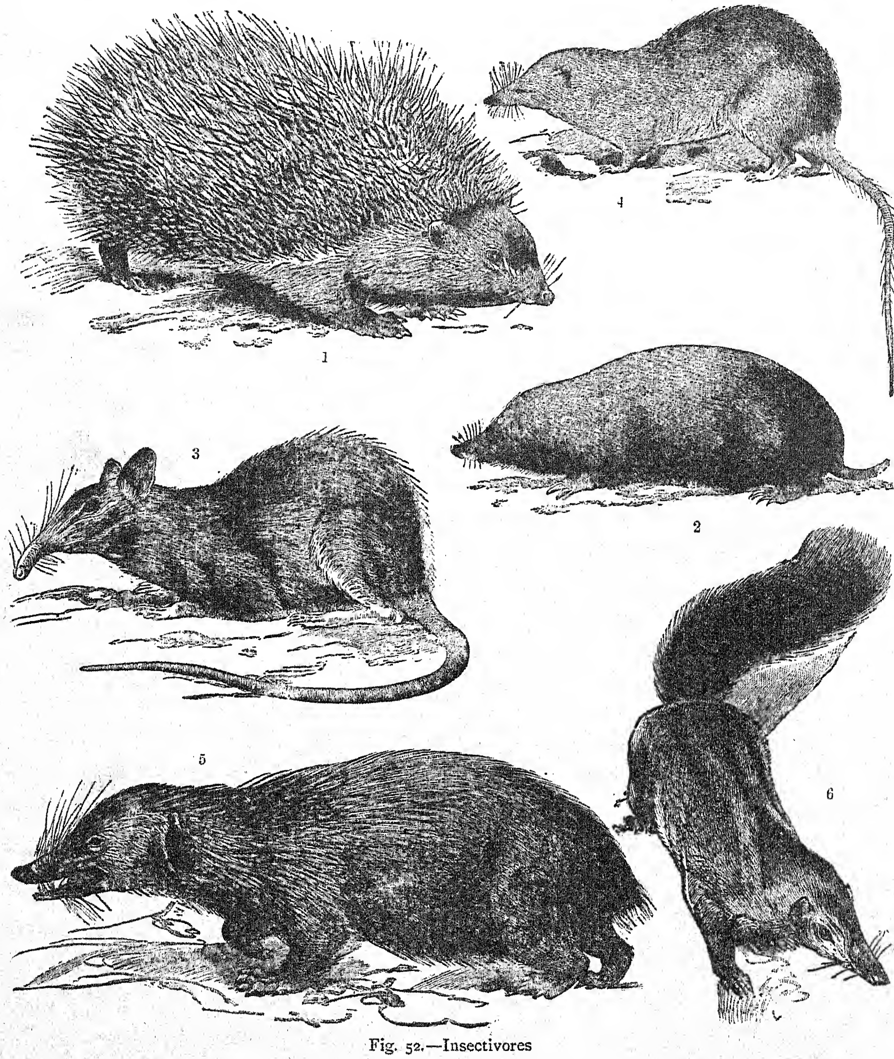


Fig. 52.—Insectivores

1, Hedgehog (*Erinaceus*); 2, Mole (*Talpa*); 3, Elephant-Shrew (*Macroscelides*); 4, Shrew (*Crocidura*); 5, Tanrec (*Centetes*); 6, Banxring (*Tupaia*).

islands. There are three British species, the Common Shrew (*Sorex vulgaris*), the Lesser Shrew (*Sorex minutus*), and the Water Shrew (*Crossopus fodiens*). The two first are the smallest British mammals, and indeed the group includes the smallest known mammals found in any part of the world, one

species, the Tuscan Shrew (*Crocidura Etrusca*), being under an inch and a half long, with a tail one inch in length.

The Common Shrew was an object of superstition in the Middle Ages, being looked upon as an enemy to domestic animals,

Fig. 53.—The Colugo or Flying-Lemur (*Galeopithecus*)

and by way of antidote it was often immured alive in a hole cut in the trunk of an ash-tree.

The Common Hedgehog (*Erinaceus Europæus*) is a well-known type of a fairly large Old World group, which may broadly be taken to include hedgehogs proper, the spineless Agouta (*Solenodon*) of Cuba and Hayti, and the Tanrecs (*Centetes*, &c.) of Madagascar, some of which are spiny. The last are adapted to very various habits.

The Common Mole (*Talpa Europæa*) is our British representative of a large group mainly distributed through the temperate parts of the northern hemisphere, and structurally modified so as to fit them for a burrowing habit. Related to them are the *Golden Moles* of the Cape, in which, however, the digits of the hand are reduced to three, and the fur has a beautiful iridescent sheen.

A remarkable animal, native to the East Indies, known as the Colugo, or Flying-Lemur (*Galeopithecus*), is probably best regarded as constituting a specialized group of the Insectivora. On each side of the body (fig. 53) there is a fold of skin which connects together the limbs and tail, and acts as a parachute, facilitating progress from one branch to another.

Order 5.—Flesh-Eaters (Carnivora)

This large, dominant, and widely distributed order of mammals includes a great diversity of widely differing forms, nearly all of which, however, are adapted for preying on weaker animals. In accordance with this the digits generally possess sharp claws, and the strong lower jaw, moved by very powerful muscles, is united to the skull by a well-marked hinge-joint (see p. 28), while large canines and cheek-teeth with cutting crowns are also characteristic. Carnivores possess considerable intelligence, particularly so in the domestic forms, such as cat and dog, and some, at least, of their senses are very acute.

The group is divided into two sub-orders—I, the true Carnivora, or Fissipedia; and II, the aquatic forms, or Pinnipedia. The former include most of the species, and Cat, Dog, and Bear may be taken as the leading types, of which the first is most specialized for flesh-eating, while the last is least so.

I. Fissipedia.—It is customary to divide the forms of this sub-order into Cats, Dogs, and Bears, using these words in a very wide sense.

CATS

These Carnivores have their feet lifted off the ground (fig. 54) so as to walk upon the digits (digitigrade), and their teeth are fewer in number and more specialized than is the case in the other two groups. There are four families:—1. Cats Proper (Felidæ);

2. Viverrines (Viverridæ); 3. Hyænas (Hyænidæ); and 4. Earth-wolves (Protelidæ).

1. *Cats Proper* (Felidæ) include a vast variety of forms, among which are the most highly specialized and the most rapacious of Carnivores. The teeth are fewer than in the other families and adapted to an exclusively animal diet, and the claws are usually prevented from getting blunt by being withdrawable into

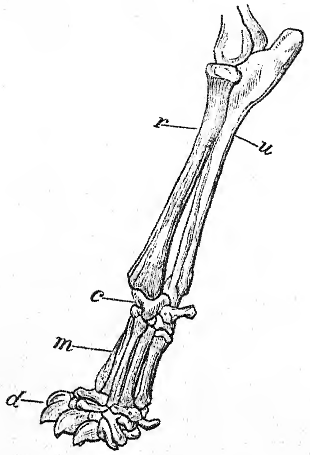


Fig. 54.—Lower part of the Fore-limb of a Lion, to illustrate the digitigrade structure. *r*, Radius; *u*, ulna; *c*, wrist-bones; *m* and *d*, bones of digits.

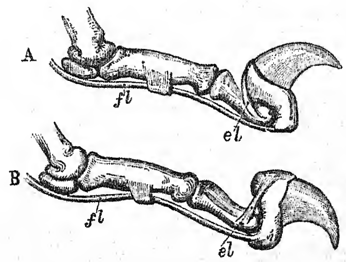


Fig. 55.—One of the Digits of a Cat, (A) with the claw in its ordinary position, (B) with the claw pulled down. *fl*, Tendon of the flexor muscle, or muscle that pulls down the claw; *el*, elastic ligament, which pulls back the claw.

special sheaths, as everyone must have noticed in the domestic cat (fig. 55). Members of the family are to be found in all the continents except Australia, and they include: (1) the True Felines, (2) the Lynxes, and (3) the Hunting Leopards.

(1) *True Felines* (genus *Felis*) have comparatively short strong legs, and differ among themselves chiefly in the matter of size and in the coloration and markings of the skin. The Lion (*Felis leo*) is the only species which, fortunately for the natives, does not possess the power of climbing trees, and the absence of stripes or spots may be noted. The mane of the male is also a characteristic feature. Lions are chiefly found in Africa, but also range into the south-west of Asia. The Tiger (*Felis tigris*) is the equal of the lion as regards both size and strength, and its stealthy habits render it much more dangerous. The dark stripes on the skin are very characteristic, and their presence makes the animal very inconspicuous in its natural surroundings. Both in Africa and Asia spotted felines are to be found, to which the names Leopard and Panther are indifferently applied. We have, for

example, the African Leopard (*Felis leopardus*) and the Asiatic Panther (*Felis panthera*), which closely resemble one another. Various small felines are native to Asia and Africa, one of them, the Fallow Cat (*Felis maniculata*), being probably the form from which the domestic animal is descended. It was venerated and embalmed by the ancient Egyptians, and its present range includes North-east Africa and part of South-west Asia. An European species, the Wild Cat *par excellence* (*Felis catus*), is probably native to Britain but is now practically limited to the more remote parts of Scotland.

All the true felines so far mentioned belong to the New World, but forms of similar kind are also found on the American continent. Of these the Jaguar (*Felis onca*), resembling a large leopard in its characters, is distributed through the whole of South America to the southern part of North America, while the Puma (*Felis concolor*), a much less dangerous form, ranges from Canada to Patagonia. There are also smaller species, *e.g.* the Pampas Cat (*Felis pajeros*), which is a native of Patagonia, and is not unlike the European Wild Cat.

(2) *Lynxes* (genus Lynx) have longer legs than the true felines, and a smaller number of teeth, indeed their dentition is more specialized than in any other carnivorous genus. They are further distinguished by tufts of hair on the tips of the ears and by the shortness of the tail. Most of them are restricted to the northern hemisphere. There are two European species, of which the smaller, the Spanish Lynx (*L. pardinus*) is only found in the Peninsula, while the Polar Lynx (*L. vulgaris*) is now chiefly found in Scandinavia and Russia (fig. 56).

(3) The third genus (Cynailurus) of the Felidæ includes the *Hunting Leopards*, which look something like ordinary leopards, but have slender limbs and non-retractile claws. Their range includes Africa and South-west Asia, and the best-known form is the Cheetah (*C. jubatus*) of the latter region, which is trained for hunting purposes.

A ferocious cat-like animal, the Foussa (*Cryptoprocta ferox*), found only in Madagascar, and sometimes considered as constituting a distinct family, may be mentioned here as a form intermediate in some respects between the present family and the one next to be described.

2. The *Viverrines* (Viverridæ) are small carnivores represented

by numerous species in the warmer parts of the Old World. The long slender body is provided with short legs, the long bushy tail tapers to a point, and the snout is somewhat long. The teeth are more numerous and not so typically carnivorous in type as in the Felidæ. Two sub-families are distinguished which differ in the

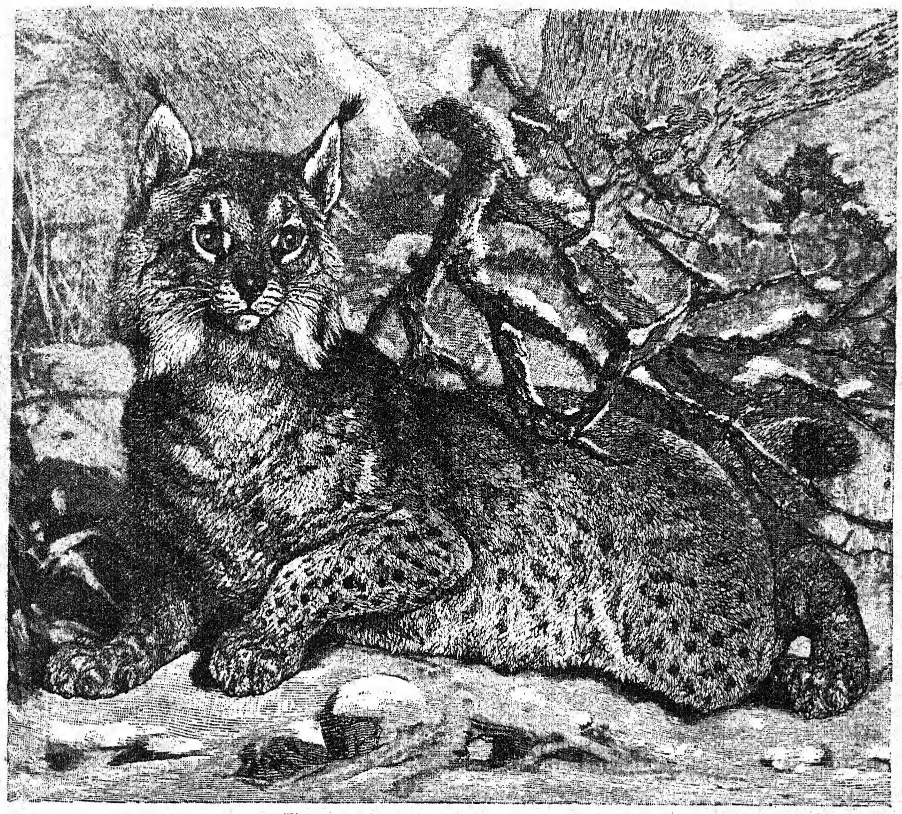


Fig. 56.—The Polar Lynx (*Lynx vulgaris*)

structure of the feet and in other ways. These are: (1) the Civets and (2) the Mangoustis.

(1) *Civets* are not unlike cats in their general appearance, and like them are digitigrade and able to retract their claws. One species, the Common Genet (*Genetta vulgaris*), is found in Spain and South France, its range also including those parts of Morocco and Algeria which are north of the Atlas Mountains. Well-known on account of the disgusting odour which they emit are the African Civet-Cat (*Viverra civetta*) and the Indian Civet-Cat (*V. zibetha*) (fig. 57).

(2) *Mangoustis* are smaller than civets, and somewhat weasel-like in appearance. The long toes are provided with non-retractile claws, and the animal does not walk in the same tiptoe fashion as the cats or civets. Most of the species are African, but some

Fig. 57.—The Indian Civet-Cat (*Viverra zibetha*)

are characteristic of South Asia, and one ranges into Europe. A common type is the Egyptian Ichneumon (*Herpestes ichneumon*), venerated by the ancient Egyptians probably on account of the services rendered by it in the destruction of snakes and the eggs of the crocodile. All sorts of wonderful stories were once current

about this animal's supposed habit of entering the crocodile's mouth for the purpose of preying upon its vitals, and its imagined knowledge of herbs acting as antidotes to the bite of a poisonous serpent. A smaller species (fig. 58), the Mungoose (*Herpestes griseus*), is undoubtedly of great use to the inhabitants of India, on account of its propensity for destroying snakes and rats. Here again natives believe that the animal is acquainted with antidotes

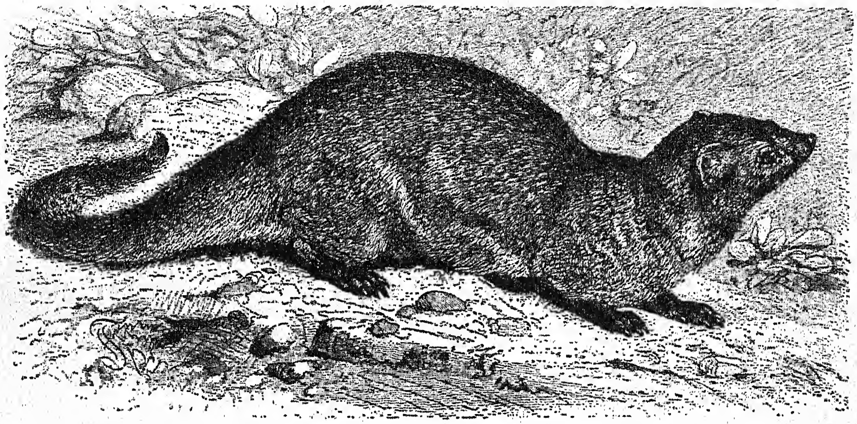


Fig. 58.—The Mungoose or Grey Ichneumon (*Herpestes griseus*)

to snake-bites. One species of Mangousti (*Herpestes Widdringtoni*) is found in the south of Spain.

3. The family of *Hyænas* (Hyænidæ) includes only three species of powerfully-built though not very large carnivores, two of which are limited to Africa south of the Sahara. A rather peculiar appearance is given by the greater length of the fore-limbs and the presence of an incipient mane. Hyænas are digitigrade, and the four toes of each foot, both fore and hind, are provided with non-retractile claws. The excessively strong jaws are provided with teeth of marked carnivorous type, and the biting apparatus is powerful enough to successfully negotiate the hardest bones. Carrion is the chief food. The Spotted Hyæna (*Hyæna crocuta*) and Brown Hyæna (*H. brunnea*) are limited to South Africa, while the Striped Hyæna (*H. striata*) has a much wider distribution, inhabiting the temperate and warm parts of both Africa and Asia.

4. The family of *Earth-Wolves* (Protelidæ) is instituted for the reception of a single species, the Earth-Wolf (*Aardwolf*) of

the Cape (*Proteles Lalandii*), which is a burrowing form looking much like a small hyæna (fig. 59). It is, however, a distinct type,

Fig. 59.—The Earth-Wolf or Aardwolf (*Proteles Lalandii*)

as shown by the insignificant cheek teeth and other anatomical characters.

DOGS

Dogs, if one includes under that term not only the species commonly so called, but also wolves, foxes, and other similar forms, are a large group of carnivores distributed over the greater part of the world. They are not so highly specialized as the cats, this being shown, for example, by the fact that their teeth are more numerous and not of so highly developed carnivorous type. The legs are long and adapted for running, and there are five toes on each fore-foot and four on each hind-foot, all provided with blunt non-retractile claws. Nearly all the members of the group belong

to the genus *Canis*, and the more robust species, with a rounded pupil to the eye, are known as *Wolves*. Of these the largest species is the Common Wolf (*Canis lupus*), which has a wide distribution through the cold and temperate parts of the northern hemisphere, and was at no very remote period a native of Britain.

Fig. 60.—The Sahara Fox or Fennec (*Canis zerda*)

As is well known, it hunts in packs, like many other dog-like animals, and this habit at times renders it formidable even to man. Few animals play a larger part in legend and fable, from the time of Æsop down to Uncle Remus. The Coyote or Prairie Wolf (*Canis latrans*) is a smaller North American species. Closely related to the wolf is the Jackal (*Canis aureus*), a much smaller animal, with a fox-like appearance. It ranges from India to Central Africa, and is also found in Greece and Dalmatia.

It has been pointed out that the domestic cat is probably the descendant of one particular wild species, but this is not the case

with dogs, these seeming to have a more varied origin. It is possible that the Dingo or Native Dog (*Canis dingo*) of Australia, which is especially interesting from the paucity of higher mammals in that continent, ought not, properly speaking, to be regarded as a wild form in the ordinary sense, but as the descendant of domesticated dogs introduced by man.

Foxes, as represented by their more characteristic species, are distinguished from wolves by a narrower snout, larger ears, shorter legs, and more bushy tail. The pupil of the eye, instead of being circular, is a vertical oval. A good type is our native species, the Common Fox (*Canis vulpes*), which is as widely distributed as the wolf, and represented by many different varieties. No animal figures more prominently in fable and legend, a somewhat exaggerated estimate being usually taken of its wisdom. Among related species the smallest and prettiest is undoubtedly the Fennec or Sahara Fox (*Canis zerda*), distinguished by the very great size of its ears (fig. 60).

BEARS

These are carnivores which walk upon the soles of the feet, or in other words are plantigrade (fig. 61), and their teeth are not so specialized as in cats and dogs, some of the molars possessing crowns adapted for crushing food instead of merely dividing it. This is in accordance with the diet, which commonly includes both animal and vegetable items.

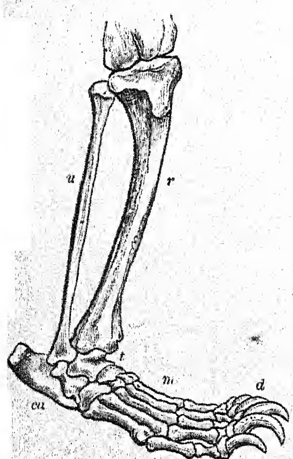


Fig. 61.—Skeleton of Hind-limb of Bear, to illustrate the Plantigrade Structure. *r*, Radius; *u*, ulna; *t*, ankle-bones; *m* and *d*, bones of digits; *ca*, heel-bone.

The group is divided into three families:—1. Small Bears (Procyonidæ); 2. Large Bears (Ursidæ); 3. Badgers, Weasels, and Otters (Mustelidæ).

1. The *Small Bears* (Procyonidæ) are probably best known in the person of the Common Raccoon (*Procyon lotor*), a very active and inquisitive creature native to the forests of North America. As the specific name indicates (Lat. *lotor*, a washer), it has the curious habit of washing its food (fig. 62).

2. *Bears* (Ursidæ) are much larger and clumsier animals, familiar to all from menagerie and zoo specimens. Though pretty

widely distributed, they are not found in Africa south of the Sahara, nor in the Australian region, and are but scantily represented in South America. The Common or Brown Bear (*Ursus arctos*) (fig. 63), which is the species once native to Britain, is

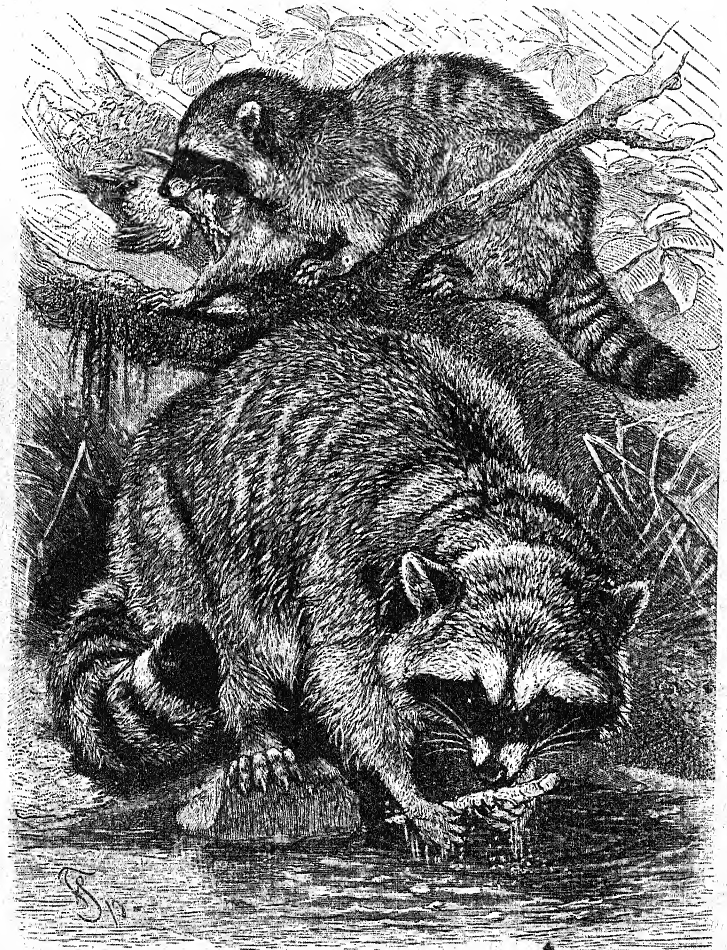


Fig. 62.—The Common Raccoon (*Procyon lotor*)

found in suitable localities throughout the whole extent of the Old World north of the Atlas and Himalaya ranges. He figures as the companion of wolf and fox in many fables and stories. Although the Brown Bear is no mean antagonist, it is surpassed both in size and fierceness by the Grizzly Bear (*Ursus ferox*) of the Rocky Mountains. The Polar Bear (*Ursus maritimus*) is of even greater size, and is indeed the largest living carnivore.

Fig. 63.—Brown Bears (*Ursus arctos*). (From an instantaneous photograph)

3. *Badgers, Weasels*, and *Otters* (Mustelidæ) together make up a family of which the majority of members are small in size, and

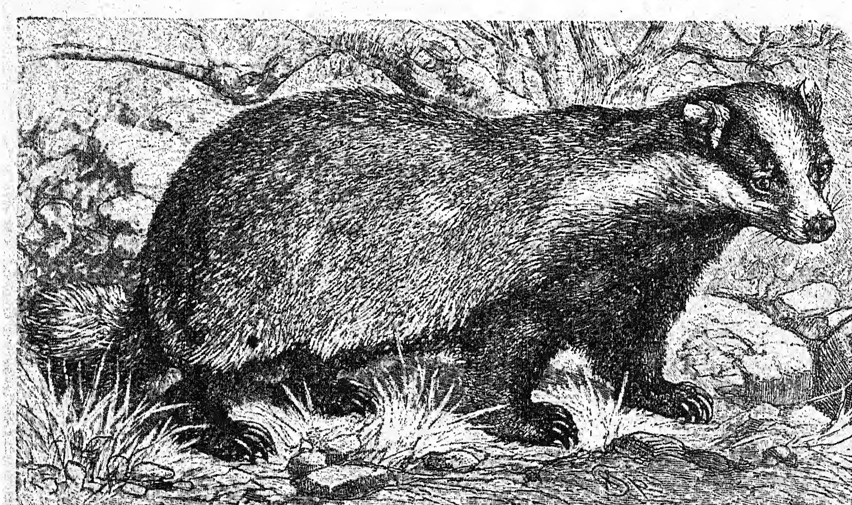


Fig. 64.—The Common Badger (*Meles taxus*)

which is of considerable economic importance since it is the source of many valuable furs.

Badgers are plantigrade forms with stoutly-built body and strong, short legs, armed with powerful claws used for burrowing. There are stink-glands opening near the root of the tail. The Common Badger (*Meles taxus*) (fig. 64) is commoner in some parts of Britain than generally supposed, for as a nocturnal and burrowing animal it is naturally seldom seen. The colour presents a reversal of the usual condition of things among animals, for the upper side of the body is light and the under side dark, instead of the opposite. Our native form ranges right across the temperate parts of Europe and Asia, from Britain to Japan. Other genera are found in Africa, South Asia, and North America. Closely related to the badgers are the *Skunks*, which range throughout both North and South America. Undoubtedly the most graceful creatures of the kind, they are at the same time the most offensive, possessing as they do the power of ejecting to a considerable distance a fluid of indescribably disgusting odour secreted by their well-developed stink-glands.

Fig. 65.—The Weasel (*Putorius vulgaris*)

Martens and *Weasels* constitute a group, of which the most typical members are small lithe animals with an elongated narrow body and a long bushy tail. Most of them are digitigrade, and the claws may be retractile. The largest British species is the Pole-cat (*Putorius fœtidus*), found in rapidly diminishing numbers

in various districts of Great Britain. Its local name of "foumart" (*i.e.* foul marten) has reference to the evil odour which it possesses, due to the same cause as in the badgers. The ferret is simply a domesticated variety of this animal. There are three other native species of marten: (1) the Stoat (*Putorius erminea*), which in its winter coat is known as the Ermine; (2) the Pine Marten (*Mustela martes*); and (3) the Weasel (*Putorius vulgaris*), which is smaller than the rest (fig. 65). The Stoat and Pine Marten are found in Ireland as well as in Great Britain.

The Sable (*Mustela zibellina*) of Russia-in-Asia is the most valuable fur-yielding member of the group, while the Glutton (*Gulo borealis*) of the Arctic regions has earned an unenviable reputation for voracity, though this has been much exaggerated.

Otters are Mustelines adapted for an aquatic life, as seen in the flattened tail and webbed feet. Our native species, the Common Otter (*Lutra vulgaris*), is found both in Europe and in Asia north of the Himalayas, including Japan.

II. PINNIPEDES (fig. 66) include sea-lions, walruses, and ordinary seals, in all of which the limbs are converted into flippers. In the first two groups the hind-limbs can be turned forward to assist in a clumsy sort of progression on land, but in the seals proper they are permanently turned backwards and bound up by folds of skin with the tail so as to form a fin.

The *Walrus* (*Trichechus rosmarus*) of the Arctic regions is remarkable not only for its flipper-like limbs but also in the reduced and specialized nature of its dentition, which is adapted for obtaining and crushing shell-fish and sea-urchins. Front teeth are altogether absent in the adult, and the upper canines are great tusks with which the food is dug up, and which also serve as weapons. There are ten cheek teeth with flattened crowns, three on each side above, and two on each side below.

The *Sea-Lions* or *Eared Seals*, so named from the presence of a small pinna, range all round the world in the colder parts of the southern hemisphere, and are also found in the North Pacific. A good type of the group is Steller's Sea-lion (*Otaria Stelleri*), which is most abundant in the neighbourhood of Behring's Straits, from which it ranges south to California and Japan. Its sharp-pointed teeth are well suited for the capture of fish.

The *True Seals* are more thoroughly adapted to an aquatic life than the two other groups of Pinnipedes, and have a much

wider distribution, being absent only from the shores of the East Indies and Africa. They are also found in some inland seas, as the Caspian, the Sea of Aral, and Lake Baikal, which is one of the proofs that these were formerly connected with the Arctic

Fig. 66.—Pinnipedes. 1, Eared Seals (*Otaria*). 2, Common Seal (*Phoca*).

Ocean. Like the sea-lions, they are adapted for preying upon fish. Five species of seal are known to British waters, of which the Common Seal (*Phoca vitulina*) may be mentioned. The commonest sort in the seas of the far north is the Greenland Seal (*Phoca Grœnlandica*), one of the chief victims to seal-fishers.

Order 6.—Whales and Porpoises (Cetacea)

The Cetaceans are mammals which are completely adapted for an aquatic life, being so much modified for that purpose as to be commonly mistaken for fishes, which they superficially resemble

in the general form of the body. Hair is practically absent in the adult, though there may be a few stiff bristles in the neigh-

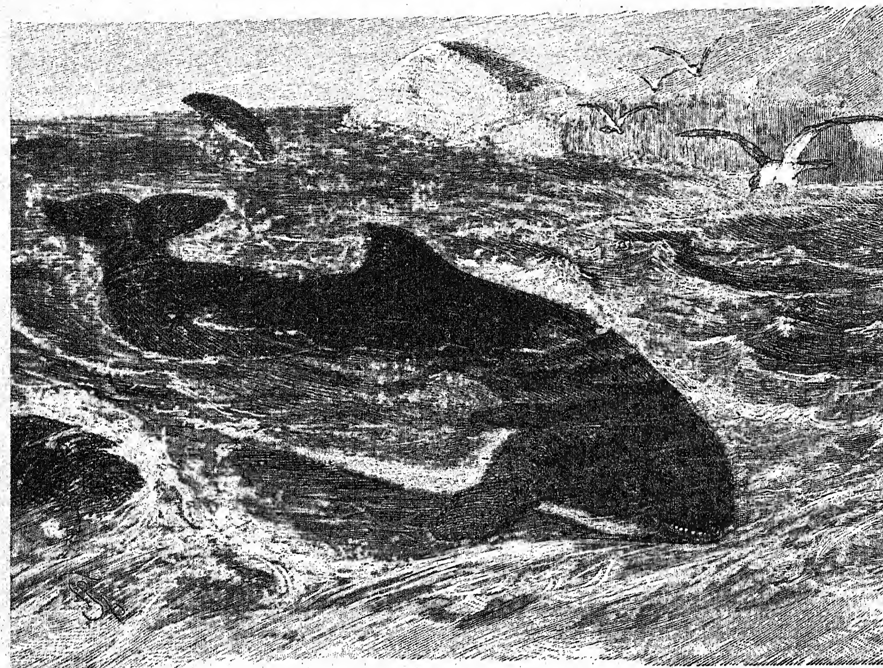


Fig. 67.—The Porpoise (*Phocæna communis*)

bourhood of the mouth, but the lack of a protective external covering is fully compensated by the thickness of the skin and by the presence of a thick layer of fat (blubber) underneath it. A tail fin is present, but this, instead of being flattened from side to side, as in a fish, is flattened from above downwards. The fore-limbs have been converted into paddles, presenting externally no trace of digits, and the hind-limbs have disappeared, though traces of them are to be found on dissection. There may be one or two nostrils, situated, for convenience in breathing, on the top of the head. Cetacea feed on other animals, ranging from comparatively large forms to small creatures which are found in huge shoals.

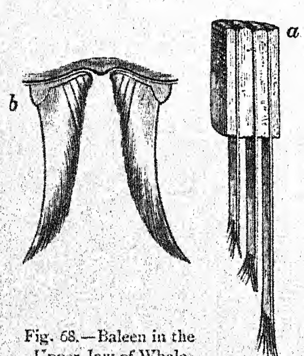


Fig. 68.—Baleen in the Upper Jaw of Whale

a, Section of a portion of the palate of a whalebone whale, showing three baleen plates. *b*, The arrangement of the baleen plates on opposite sides of the jaw.

The Porpoise (*Phocæna communis*) (fig. 67), which possesses

numerous simple teeth, is a familiar British species, while the Greenland or Right Whale (*Balæna mysticetus*) is an example of the large toothless forms, which feed on shoals of minute marine organisms, from which the water is strained by numerous plates of whalebone (baleen) projecting downwards from the palate (fig. 68).

Order 7.—Sea-Cows (Sirenia)

This small order includes only two living genera of aquatic mammals, inhabiting the shores of the Atlantic and Indian Oceans,

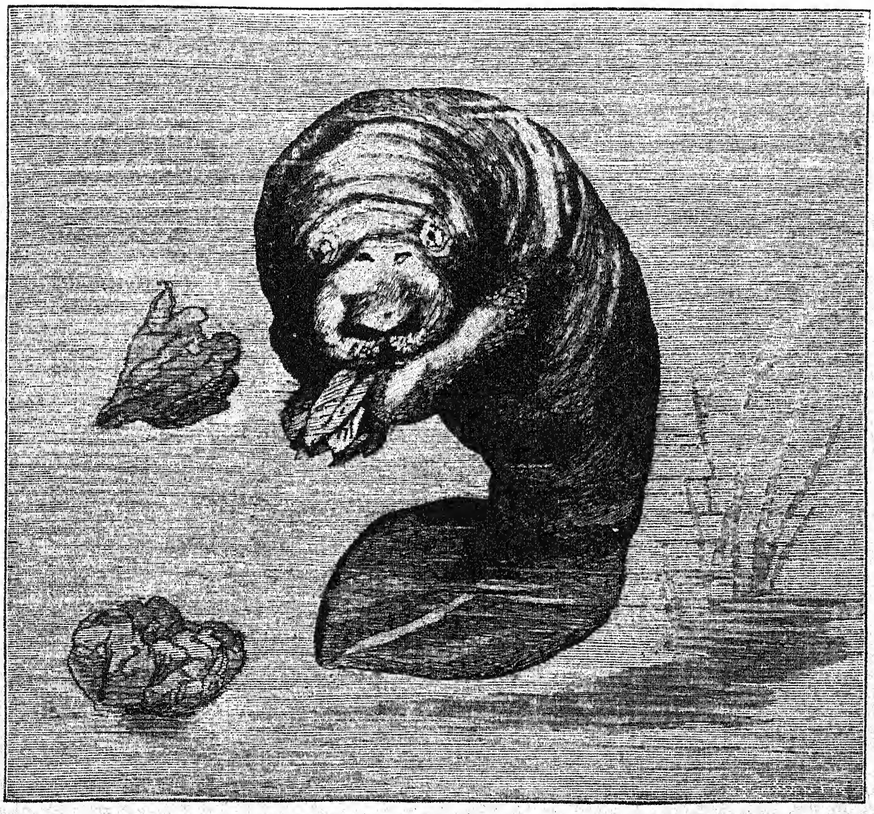


Fig. 69.—The Manatee (*Manatus*)

and also making their way up some of the large rivers. As might be expected, considering their mode of life, they are shaped not unlike Cetaceans, with which they agree in the general shape of the body, absence of hind-limbs, and possession of a horizontally-flattened tail fin and flipper-like fore-limbs. They are not, however, quite so much specialized, for there is a fairly-well-marked

neck, and the nostrils are situated at the end of a broad muzzle, provided with thick fleshy lips beset with moustache hairs. There are also eyelashes, and the thick skin is covered with short stiff hairs. They subsist entirely on vegetable food, and simple grinding teeth are present in both genera. A pair of mammary glands are found on the breast.

The Dugong (*Halicore Dugong*) is 16 or 17 feet long, and frequents the shores of the Indian Ocean, while the somewhat smaller Manatee (*Manatus*) (fig. 69) is found on the west coast of Africa and the east coast of America, from the Gulf of Mexico southwards. A certain interest attaches to these creatures from the fact that they appear to be the chief foundation for legends of mermaids and mermen. It requires a pretty vivid imagination, however, to see any resemblance in these uncouth animals to the golden-haired conventionalities which have gradually been evolved from the inner consciousness of artist and poet.

Order 8.—Elephants (Proboscidea)

These familiar mammals, the largest of existing land animals, are in many respects primitive in structure, particularly as regards the limbs, which possess five digits, united together into flat rounded feet, provided with a varying number of small hoofs. The limbs are very thick and pillar-like, being thus enabled to support the enormous weight of the body. Elephants, however, are very highly specialized as regards the structure of the head, of which the most striking feature is the trunk, or prolonged snout, at the end of which the nostrils are situated. The uses of this remarkable organ are innumerable, and there can be no doubt that its development has led to a corresponding growth of intelligence. The teeth are highly peculiar, only two kinds, incisors and molars, being present. Of the former only an upper pair exists, modified in the male, or it may be in both sexes, into the well-known tusks, which are composed entirely of ivory or dentine (see p. 35). The molars are enormous, and possess broad grinding crowns, provided with numerous transverse ridges (fig. 70). For the most part only four are in place at once, one on each side

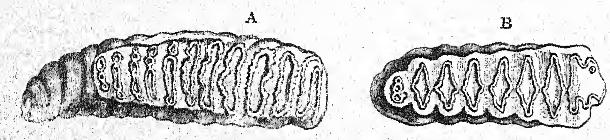


Fig. 70.—A, Last Lower Tooth (molar) of Indian Elephant. B, Last Lower Tooth (molar) of African Elephant.

of either jaw, and they are replaced by others which grow from behind and gradually push out their predecessors as these get worn away. It is scarcely necessary to remark that in the vast majority of mammals teeth are succeeded by others which grow up vertically below them. The skull of an adult elephant is of remarkable form, and the cranium is much larger than the brain

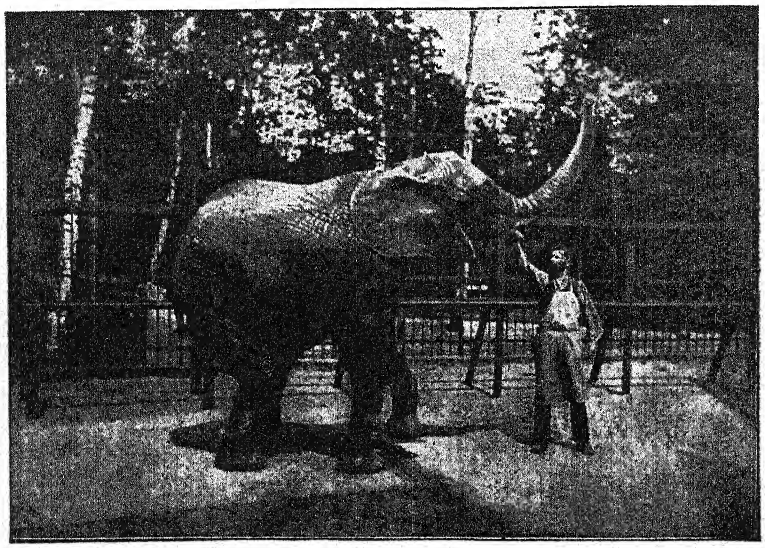


Fig. 71.—African Elephant (*Elephas Africanus*). (From an instantaneous photograph)

which it contains, owing to the excessive development in its roof of air-chambers separated by complex bony plates. It may lastly be noted that the thick skin is but sparsely covered with hairs, and that the mammary glands are situated between the fore-limbs. The food consists exclusively of vegetable matter.

Elephants are now represented by only two species, one the Indian form (*Elephas Indicus*), found also in Ceylon, Borneo, and Sumatra, while the other (*Elephas Africanus*) is limited to Africa south of the Sahara (fig. 71).

Order 9.—Conies (Hyracoidea)

This small order includes only certain little creatures about the size of a rabbit, which inhabit the deserts of Africa and Syria. The general resemblance to a rabbit is seen chiefly in the cleft upper lip, and the presence of two long upper incisors which grow continuously, while canine teeth are entirely absent. In the

character of the cheek teeth, however, and in the nature of the digits they are much more like the tapir and rhinoceros. Each fore-foot has four toes, and each hind-foot three, all of which, except the innermost toe of the hind-foot, which is clawed, possess small rounded hoofs.

The "coney" of the English Bible, otherwise known as the Syrian Hyrax (*Procavia Syriaca*) may be taken as a type. "The

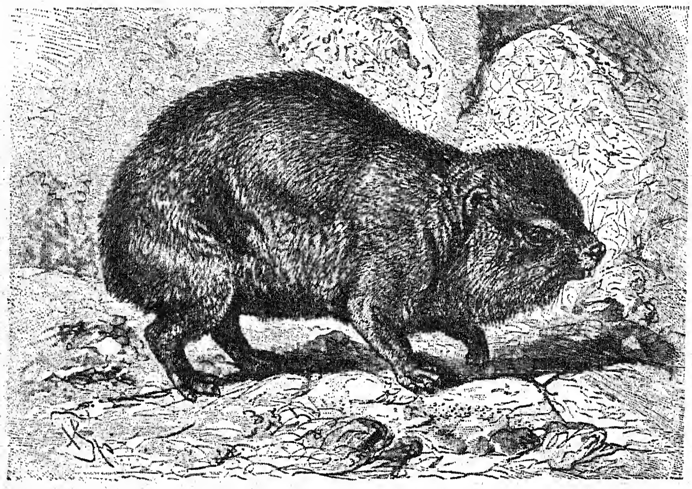


Fig. 72.—The Abyssinian Hyrax (*Procavia Abyssinica*)

conies are but a feeble folk, yet make they their houses in the rocks" (Prov. xxx. 26). The illustration (fig. 72) represents a similar species, the Abyssinian Hyrax (*P. Abyssinica*).

Order 10.—Hoofed Mammals (Ungulata)

This very large and important order includes animals in which the limbs are modified for the sole purpose of terrestrial progression, while the organization generally is adapted to the herbivorous habit, as more particularly seen in the grinding crowns possessed by the cheek teeth.

Two sub-orders are recognized: I. the Odd-toed Ungulates (Perissodactyla); and II. the Even-toed Ungulates (Artiodactyla)

I. Odd-toed Ungulates (Perissodactyla).—This sub-order embraces the three families of: 1. Tapirs, 2. Rhinoceroses, and 3. Horses, in all of which there is an odd number of toes on the hind-foot, and generally on the fore-foot as well. A much more important distinction, however, is found in the fact that the third

digit dominates over the rest and is symmetrical in itself, continuing the direction of the limb-axis.

1. The *Tapirs* in general appearance are not unlike large pigs, but the symmetry of the feet is quite different, and so is the number of the toes, there being four on the front, and three on the hind foot, all provided with hoofs. A pig has four toes on every foot. The snout is drawn out into a short proboscis, which

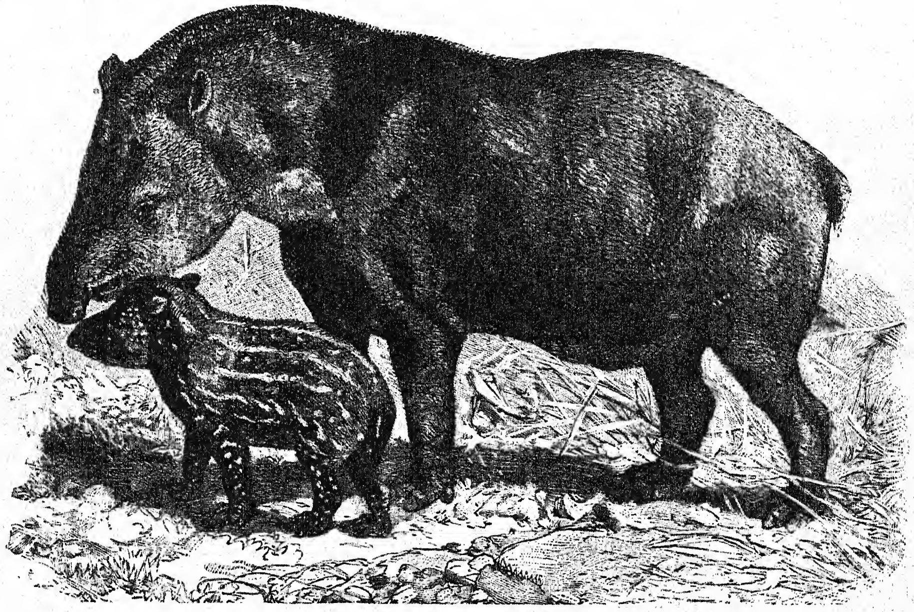


Fig. 73.—The Brazilian Tapir or Anta (*Tapirus Americanus*)

suggests what the incipient proboscis of the ancestors of elephants was probably like. Tapirs present a remarkable case of the phenomenon known as "discontinuous distribution", where a species or some larger group inhabits two or more areas more or less remote from one another, while it is absent from the intermediate space. In this instance the disconnected areas are South and Central America on the one hand, and the Malay region on the other. The species commonly seen in zoological gardens is the Brazilian Tapir (*Tapirus Americanus*) (fig. 73).

2. *Rhinoceroses* are huge clumsy-looking animals of little intelligence and surly disposition. The massive head, borne on a short thick neck, is characterized by its small eyes, oval erect ears, and one or two unpaired horns on the upper side of the snout. It is indeed the possession of such a horn which is the most

striking feature, giving the common name of the animal (Gk. *rhīnós*, of the nose; *kéras*, a horn), and it is probably responsible for the creation of the legendary unicorn. This defensive structure, when examined microscopically, is seen to be made up of innumerable horny fibres cemented together, and it has been aptly compared to a big wart, for there is no connection between it and the underlying bone. The African natives have a curious superstition that cups made from this horny material destroy the potency of any poisoned drink which may be poured into them.

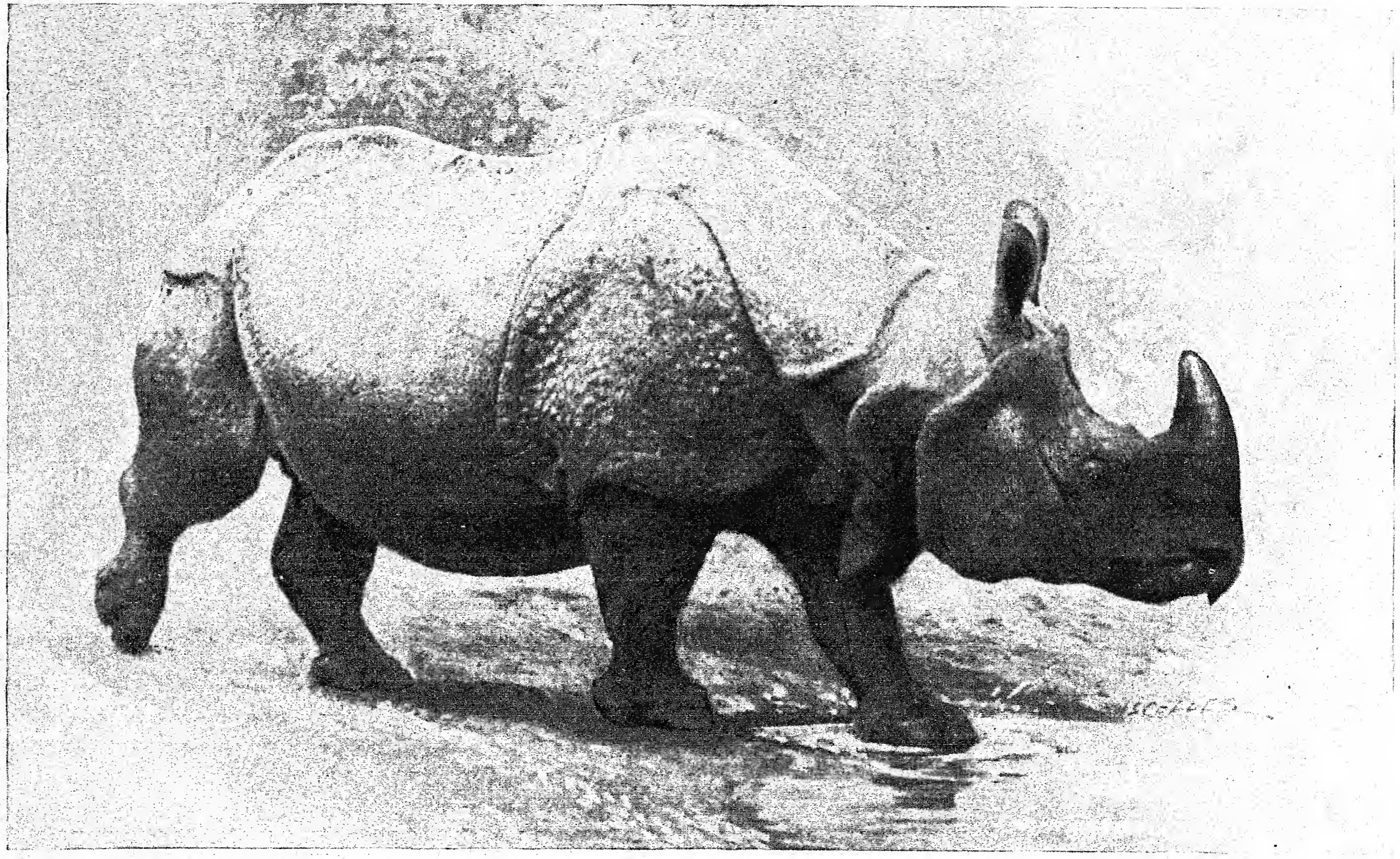
Each one of the four extremities ends in three toes, provided with strong hoofs, there being thus a reduction in the fore-foot as compared with tapirs. The skin is exceedingly thick and but scantily provided with hair, though there is a well-marked tuft on the end of the short tail. The snout is not produced into a proboscis, but the upper lip is extremely flexible. The teeth are well adapted to a vegetable diet, for the grinders have broad crushing crowns of peculiar and characteristic pattern. Upper canines are absent, and sometimes lower ones too. There is much variability in regard to the front teeth, and in the adult these may be absent altogether.

The group is at the present time confined to South Asia and Tropical Africa, and typical species are the one-horned Indian Rhinoceros (*Rhinoceros Indicus*), in which the thick skin is disposed in remarkable armour-like folds, and the Common Rhinoceros (*Atelodus bicornis*) of Africa, the skin of which is relatively thin and devoid of folds, while there are two well-developed horns placed close together.

3. *Horses* and their immediate allies are decidedly the most highly specialized of the odd-toed Ungulates. All the living species belong to the single genus *Equus*, the external characters of which are too well known to need description. It may, however, be noted that the long legs, well suited for swift running, possess but one externally visible toe, corresponding to the middle one of five-toed forms, and provided with a rounded hoof. The front teeth are well developed, and each of them has a deep indentation in the crown, which gets filled up with fragments of the food, and is the cause of the black central area commonly known as the "mark". The canines are reduced and often absent in the female, but the cheek teeth are numerous, and their flattened crowns exhibit an exceedingly complex pattern.

THE INDIAN RHINOCEROS (*Rhinoceros Indicus*)

The living species of Rhinoceros are native only to Africa and South Asia, although, as shown by geological evidence, animals of the kind were once very widely distributed, and some of them inhabited prehistoric Britain. The group is known to have originated in North America. The common Indian species represented ranges from Bengal to Cochin-China, and is the kind which figured in the gladiatorial displays of the ancient Romans. It is distinguished by the possession of a single horn upon the nose, and armour-like folds in the thick skin.



THE INDIAN RHINOCEROS (RHINOCEROS INDICUS)

A STUDY FROM THE LIFE

The domesticated Horse (*Equus caballus*) has such a long history of captivity that its ancestry is obscure, and it is by no means certain that all horses have descended from one stock. It is, however, generally believed that one original stock was Asiatic, and perhaps the Tarpan or Wild Horse (*Equus tarpan*) of Central Asia comes nearest to this stock, though even that is far from being certain. *Wild Asses* are found both in Africa and Asia, and the domesticated form familiar to us comes nearest to an Asiatic species, the Onager (*Equus onager*), which ranges from Asia Minor to India. The domestic asses of Egypt and Abyssinia, however, more closely resemble the African Wild Ass (*Equus tæniopus*), native to the region between the Red Sea and Nile. The remaining living equines are those striped African species known as *Zebras* or *Tiger Horses.* The kind most commonly seen in zoological gardens is Burchell's Zebra (*Equus Burchelli*), herds of which are still to be found in the grassy plains to the north of the Orange River.

II. Even-toed Ungulates (Artiodactyla).—This large and important group of Ungulates includes not only many valuable domesticated forms, such as swine, oxen, goats, sheep, and camels, but such familiar types as hippopotamus, antelopes, llama, and giraffe. The even number of the toes is a character of far less importance than the symmetry of the foot, there being no single digit which is symmetrical in itself, like the third or middle one in the preceding group.

Two sections are recognized:—A. Non-ruminating forms; and B. Ruminants.

A. *Non-Ruminating Forms*

This includes: 1. the Hippopotamus Family, and 2. the Pig Family, in neither of which are the digestive organs modified for the purpose of ruminating or "chewing the cud". They belong, therefore, to the "unclean animals" of the Levitical law, despite their cloven feet (Lev. xi).

1. The *Hippopotamus Family* is entirely confined to the rivers of Africa, with the adjacent swampy ground, and is represented by two living species, *i.e.* the small Liberian Hippopotamus (*Hippopotamus Liberiensis*), limited, so far as known, to Liberia, and the Common Hippopotamus (*H. amphibius*), the large form frequently seen in captivity, which has a much wider range. The appearance

of this huge lumbering creature, which weighs about 2½ tons, suggests a parody on the pig, or a large barrel mounted on four stout ungainly legs. Each foot possesses four toes provided with rounded hoofs. The head is enormous, and the snout greatly swollen. The thick skin is almost devoid of hair, and is thrown into folds above the limbs. Those who have noticed a captive hippo open its tremendously wide mouth will have seen a truly terrific dentition displayed. Above are four peg-like incisors flanked by large canines, while below there are two huge cylindrical incisors, two smaller incisors, and formidable tusk-like canines (fig. 74). A full complement of grinding teeth is present, and the large molars, when their crowns are worn, exhibit a pattern resembling a double trefoil. The hippopotamus was well known to the ancients, and is the behemoth of Scripture.

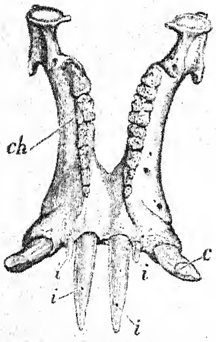


Fig. 74.—Lower Jaw of Hippopotamus

ch, The cheek teeth, originally tubercled, but worn down by use so as to present the appearance of clover-leaves bordered by bands of enamel: *i*, incisors; *c*, canines.

2. The *Pig Family* has a wide distribution both in the Old and the New World. Well-marked features are the bristly skin, flexible snout tipped by a fleshy disc within which the nostrils open, teats extending right along the under side of the body, and legs of moderate length and thickness. There are four toes on each foot, the two central ones only reaching the ground, and being of relatively large size. The most illustrative type is the Wild Boar (*Sus scrofa*), once a native of Britain, and which at the present time ranges throughout Europe, Asia, and North Africa. It appears to be the original stock from which the domestic pig has been derived. The teeth are numerous and of primitive type, the points of greatest interest being the tusk-like canines, all four of which are upwardly directed, and the grinding teeth, which possess tuberculated crowns.

In Africa south of the Sahara the Wild Boar type is replaced by forms in which there are swellings on the face caused by underlying bony projections. These are comparatively small in the Red River-Hog (*Potamochœrus penicillatus*) of Guinea, which is further distinguished by a tuft of hair at the tip of each ear; but in the *Wart-Hogs* they are of large size, and give the enormous head a particularly forbidding appearance. There are two species, one (*Phacochœrus Æthiopicus*) being found at the Cape,

while the other (*Ph. Africanus*) is much more widely distributed.

In Celebes and the adjacent islands a remarkable pig is found known as the Babirussa (*Porcus babirussa*), in which the lower tusks are like curved daggers in shape, while the upper tusks curve back over the face almost like horns. The natives say that the animal hangs itself up by these when it wishes to sleep peacefully.

In America, from Mexico southwards, the pigs are represented by small forms called *Peccaries*, one species being the Collared Peccary (*Dicotyles torquatus*).

B. *Ruminants*

The members of this section agree with the pigs in possessing on each foot only two toes which reach the ground, in addition to which there may or may not be two smaller digits, but they differ markedly from pigs in the greater length of their limbs, which are eminently adapted for rapid progression. The most characteristic feature, however, is to be found in the possession of a very complex stomach, adapted for ruminating; *i.e.* the food is first swallowed without chewing, and then returned to the mouth in successive portions for leisurely mastication in a safe place. The cheek teeth have grinding crowns, provided with crescentic ridges, and (except in camels) the upper incisors are replaced by a hard pad. The following families together constitute the section:—1. Chevrotains; 2. Deer; 3. Prongbucks; 4. Oxen and their allies; 5. Giraffes; and 6. Camels.

1. The *Chevrotains* are a restricted group, including the smallest and least specialized ruminants, approaching the peccaries in some structural features. In appearance they suggest diminutive hornless deer, and on this account are sometimes called Mouse-Deer. There are no upper incisors, and the upper canines of the male are slender, downwardly-directed tusks. Of the six existing species five belong to the genus *Tragulus*, and are distributed through South Asia from India eastwards. The smallest species is the Malay Kanchil (*Tragulus Javanicus*) (fig. 75), than which only one other Ungulate, *i.e.* the Royal Antelope, is of less size. The sixth species of this family is the Water Chevrotain (*Dorcatherium aquaticum*), which is only found on the west coast of Africa.

2. The *Deer Family* includes a large number of species, widely distributed throughout both hemispheres, though absent from Africa south of the Sahara. There are four toes to each foot, all being provided with hoofs, but the supporting bones of the extremities are rather more specialized than in the Chevrotains. The leading characteristic of the family is undoubtedly the possession of antlers by the male in nearly all cases. These structures are essentially bony outgrowths from the skull, which are annually shed, and in many cases become more complex in shape each successive year so as to be an indication of age. The young antlers are composed of living bone and are covered by a continuation of the skin ("the velvet"). When their full size is attained the base of the antler grows out into a ring-like projection (the "burr"), cutting off the blood-supply from the skin, which consequently peels off from the underlying bone, causing this to become dead and hard. A further characteristic of deer is the presence of a pit in front of each eye, within which certain glands open.

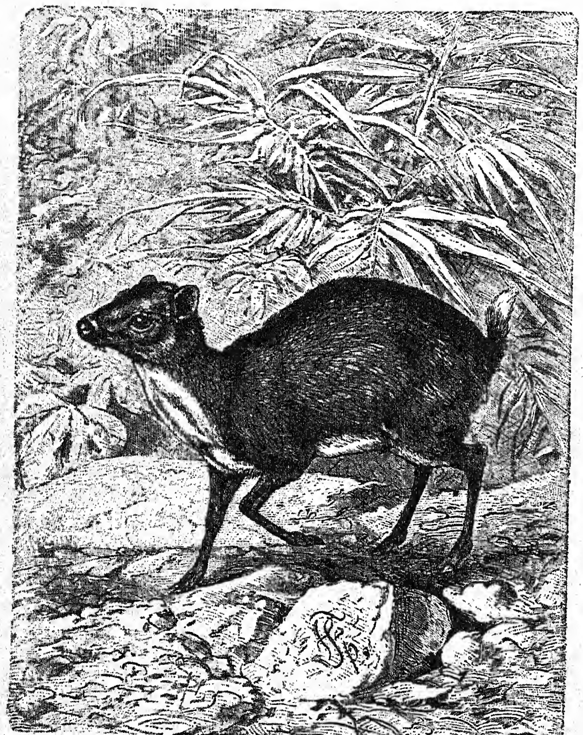


Fig. 75.—The Kanchil (*Tragulus Javanicus*)

It is convenient to first mention the Musk Deer (*Moschus moschiferus*, because it differs considerably in structure from all other members of the group, having, *e.g.*, a less complex brain, and possessing a gall-bladder, which organ is absent in other deer. There are no antlers, and the upper canines of the male resemble those present in Chevrotains. Most of the musk of commerce is obtained from a pouch situated pretty far back on

the under side of the body in the male. Musk Deer are active creatures inhabiting the high land of Central Asia.

The Chinese Water Deer (*Hydropotes inermis*), which lives on the banks of the Yang-tse-Kiang, shares with the preceding species the two primitive characters of tusk-like upper canines and absence of antlers in the male. This does not, however, indicate any special relationship between the two forms.

The Red Deer (*Cervus elaphus*) is still numbered among British mammals, though in the wild state it is now restricted to the remoter parts of Scotland and Ireland, with isolated patches in England. It is characterized by the complex antlers (fig. 76), which have a brow-tine projecting over the forehead, a bez-tine above this, and, in mature specimens, a terminal cluster of twelve or more points. Outside Britain this species has a wide distribution through the temperate parts of Europe and Asia.

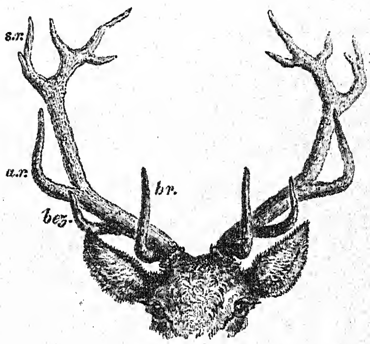


Fig. 76.—Antlers of Red Deer
br. Brow-tine; *bez.* bez-tine; *a.r.* antler royal; *s.r.* sur-royal.

The large Wapiti (so-called "Elk") of North America (*Cervus Canadensis*) is closely allied to the Red Deer. Ranging at one time over most of North America, it is now restricted to the mountainous parts of the Western States and to British territory in the north.

The familiar Fallow Deer (*Cervus dama*) is not a native of these islands, though introduced at an early date, but is indigenous to the Mediterranean countries. It is much smaller than the Red Deer, and the antlers are of different formation. They are said to be "palmated", *i.e.* ending in a broad expansion divided into points, and compared to a hand with its fingers. Below this expanded portion is a branch called the trez-tine, and a good way below this a prominent brow-tine juts out.

Great interest attaches to the Reindeer (*Rangifer tarandus*) for several reasons, one being their great importance to certain primitive peoples as domestic animals. At the present time they are limited to the northern parts of both hemispheres, but in prehistoric times, when the climate of the northern hemisphere was much more rigorous than now, their range extended much farther south, as evidenced by remains found in the

caves of Britain and other countries. Indeed they were so characteristic of a stage in human history, when carefully-chipped stone weapons and implements had replaced the cruder attempts in this direction, that the term "Reindeer Age" is often applied to the period in question. A marked peculiarity is the presence of antlers in both sexes, these structures being of great length and set on far back. There is a brow-tine, greatly developed and branched in the male, just above this a bez-tine, and then a long beam, the end of which is palmated. The two antlers are commonly markedly unlike one another. The main hoofs are very broad and flat, and separate when the feet are brought to the ground, afterwards clapping together in a curious way when the feet are raised.

The largest living species of deer is the Elk or Moose (*Alces machlis*), the distribution of which roughly corresponds to that of the reindeer, though it does not range into those extreme northerly regions from which trees are absent. The long head terminates in a muzzle of curious humped appearance, suggesting a Roman nose; the neck is short, and the body slopes markedly from front to rear. The long legs are provided with broad hoofs. Many peculiarities are presented by the massive antlers, which, beginning with short beams devoid of tines, expand laterally into broad palmated portions. A curious feature of the male is the presence of a flap of skin hanging down from the under side of the neck.

The remaining species of which space permits a mention is the little Roe Deer (*Capreolus caprea*), our second native form, though now only found in Scotland as a truly wild animal. From Britain it ranges east through Europe into Persia. The rough antlers are of simple conformation. The beam rises vertically from the top of the head, gives off a front tine about the middle of its length, and then curves back to end in a simple fork.

3. The *Prongbuck Family* contains only the single species (*Antilocapra Americana*), to which it owes its name (fig. 77). It is a small active animal found in the temperate parts of western North America. Although in appearance suggesting a deer, its affinities are rather with the antelope section of the family of oxen. The horns, however, present a remarkable peculiarity, for though they consist of bony cores covered by horny sheaths, as in an

antelope, they are shed annually, which is not the case with the last-named form, and a further difference is seen in the presence of a small front branch. The two peculiarities mentioned

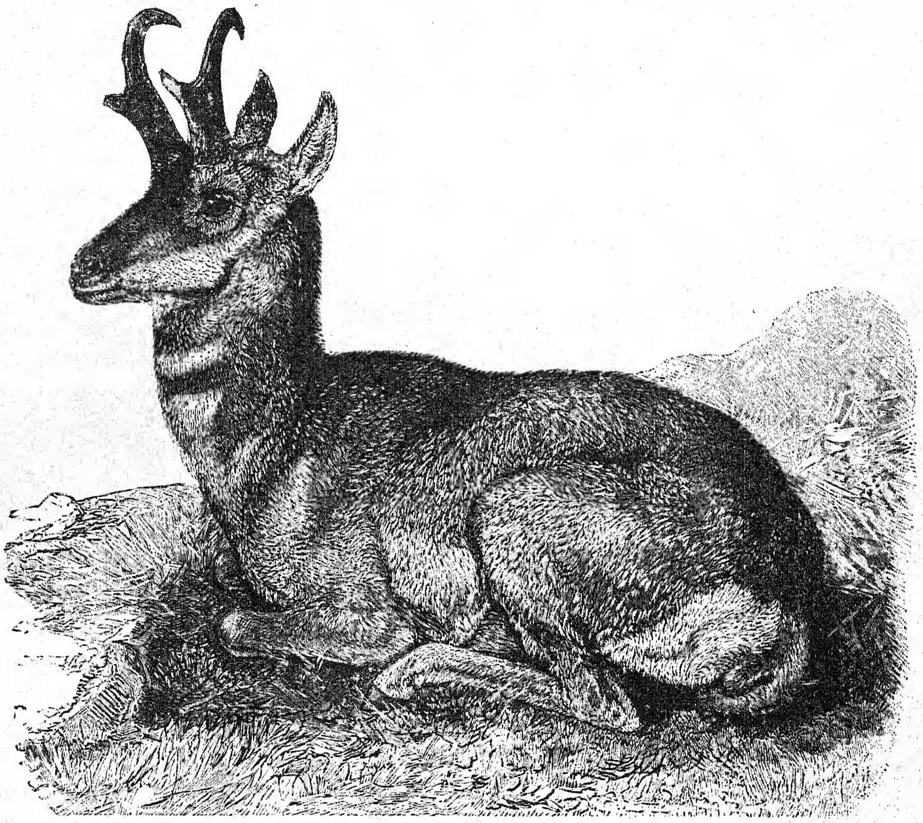


Fig. 77.—The Prongbuck (*Antilocapra Americana*)

suggest antlers, but otherwise there is no reason for classifying Prongbucks with the deer.

4. The *Ox Family* is an exceedingly large one, including those forms which are commonly known as hollow-horned ruminants (Cavicornia), because the unbranched horns, which are never shed, consist of hollow horny sheaths borne upon bony outgrowths from the skull. They may be present in both sexes, or else restricted to the male. The upper incisors and also the canines are absent, their place being taken by a horny pad, against which the lower front teeth bite, as in deer, prong-bucks, and giraffes. The feet are much like those of deer, each possessing two large toes shod

with hoofs, two other toes being commonly represented by small hoofs, though these may be in this case absent altogether. The family not only includes (1) oxen in the widest sense, but also (2) sheep, (3) goats, and (4) antelopes. With but few exceptions, these are found only in the Old World.

(1) As in the case of so many other domesticated forms, there is considerable doubt as to the ancestry of European *oxen* (*Bos taurus*), but there can be little doubt that these are largely descended from the Auroch or Urus (*Bos primigenius*), which was hunted by prehistoric man and existed as a wild species so late as the twelfth century, though they are now known only as half-wild cattle of comparatively small size, the best known of these being the herd preserved at Chillingham in Northumberland. In this case the muzzles and ears are red (though at an earlier date they were black), while the rest of the body is white.

A different origin must be sought for the *humped cattle* of Africa and India, the latter often receiving the name of Zebu (*Bos indicus*). It has been claimed that these are descended from an African stock, though this is only conjectural, and it may be observed that there are several wild species of Asiatic oxen which exhibit the humped character to a greater or less degree. This is the case, for example, with the Gaur (*Bos gaurus*) of India and Further India, to which the name "bison" is often misapplied, and the Yak (*Bos grunniens*) of Thibet, distinguished by its long hair and horse-like tail.

The group of *Bisons*, to which in some respects the Yak approximates, are distinguished by several special features, among the most striking of which are the great disproportionate height of the front part of the body and the projection of the back of the head above the origin of the horns. The European Bison (*Bos bonassus*), once abundant, is now practically restricted to Lithuania and the Caucasus, and appears doomed to extinction, like the American Bison (*Bos Americanus*) (fig. 78), which existed in countless herds at no very remote period. Under the name of "buffalo" this animal plays a large part in various kinds of literature dealing with North America.

Buffaloes, using the term in the strict sense, are stoutly-built oxen with broad snout, strong thick horns, and large fringed ears set on rather far down. The hair is comparatively coarse and scanty, and the long tail is tufted. The group is characteristic

of the warmer parts of the Old World, and the most powerful species is the Cape Buffalo (*Bos caffer*), which has a wide distribution in Africa. While in this form the broad bases of the horns meet together in the middle, the long backwardly-directed horns of the much smaller Indian Buffalo (*Bos bubalus*) are separated by a wide interspace. As a wild animal it is confined to

Fig. 78.—The American Bison (*Bos Americanus*). (From an instantaneous photograph)

India, but in the domesticated condition has a wide distribution through south-east Asia, and has also been introduced into Asia Minor, Egypt, and Italy.

The Musk Ox (*Ovibos moschatus*) (fig. 79) with its ram-like horns is more of the nature of a sheep than an ox. At the present time it is restricted to the arctic parts of the western hemisphere, and it is remarkable that so large a creature is able to find a sufficiency of vegetable food in such inhospitable wilds. Its name is due to the peculiar musky flavour which the flesh possesses.

(2) *Sheep* resemble oxen in many respects but are much smaller animals, and the neck bends sharply up, so that the head

is carried comparatively high. Although in many wild forms horns are present in both sexes, those of the male are specially characteristic. Their form is more or less spiral, with the tips turned outwards; they are triangular in section, and marked by numerous transverse wrinklings. The snout is pointed, and there is usually a glandular pit below the eye, the tail is short, and a

Fig. 79.—The Musk-Ox (*Ovibos moschatus*)

bottle-shaped gland opens between the central toes of each foot. Of the eleven existing wild species nine inhabit the mountainous parts of Europe and Asia north of the Himalayas, while the remaining three belong respectively to North-west India, North Africa, and North America. The Bighorn (*Ovis Canadensis*) and Mouflon (*O. musimon*) may be taken as illustrations. The former ranges through the mountains of western North America from Alaska to Mexico, while the latter is at the present time only found in Corsica and Sardinia.

The same doubt attaches to the origin of tame sheep, which

have been domesticated from prehistoric times, as to that of most other farm-animals.

(3) *Goats* agree with sheep in many respects, but in typical cases are distinguished by the concavity of the face, peculiar hard patches on the knees, absence of glandular pits below the eye, and lack of hoof-glands in the hind-feet. The male is characterized by a peculiarly unpleasant odour, strong backwardly-curved horns, often with a corrugated surface, and a tuft of hair on the chin. The group is essentially characteristic of the mountainous axis of the Old World, from Spain eastwards to Thibet and North China, but outlying species occur in South India, Africa, and North America. The species known as the Bezoar Goat or Grecian Ibex (*Capra œgagra*), which ranges from some of the Greek islands eastwards to Persia, where it is called the pasang, is interesting as being probably the chief stock from which the Domestic Goat (*Capra hirca*) is derived. Goats are known to have been tamed from very early times, and Homer, in describing those of the Cyclops, was no doubt alluding to this particular species, which formerly had a much wider range in Greece.

Among other species may be mentioned the Spanish Ibex or Wild Goat (*Capra Pyrenaica*), the almost extinct Alpine Ibex (*C. ibex*), the Himalayan Ibex (*C. Sibirica*), and the Arabian Ibex (*C. Sinaitica*). The solitary American species is the Rocky Mountain Goat (*Haploceros montanus*), which ranges through the Rocky Mountains from California to Canada. It is not a very typical goat, and forms one of a small group of genera intermediate in character between goats and antelopes.

(4) *Antelopes* constitute a large group of hollow-horned ruminants difficult, if not impossible, to define, but including those members of the family which are obviously neither oxen, sheep, nor goats. There are, however, many transitional forms, such as the one last mentioned under the heading of goats. The group is now characteristic of Africa, Syria, and Arabia, though there are a number of outlying species. A typical antelope is elegant in form, with head carried well above the body and bearing graceful horns, prominently ringed, and straight, simply curved, or twisted. The bony horn-cores are of more solid nature than in the other divisions of the ox family, and there is frequently, as in sheep, a glandular pit below the eye.

The Chamois (*Rupicapra tragus*) is one of the transition forms

between goats and antelopes, so that it may be placed indifferently in either of them. It ranges from the Pyrenees to the Caucasus, and is the only animal in West Europe which has any claim to the name of antelope. A characteristic feature is seen in the sharp hook-like termination of the short black horns.

Among the most graceful members of the group are the small desert forms which, under the name of *Gazelles*, have been immor-

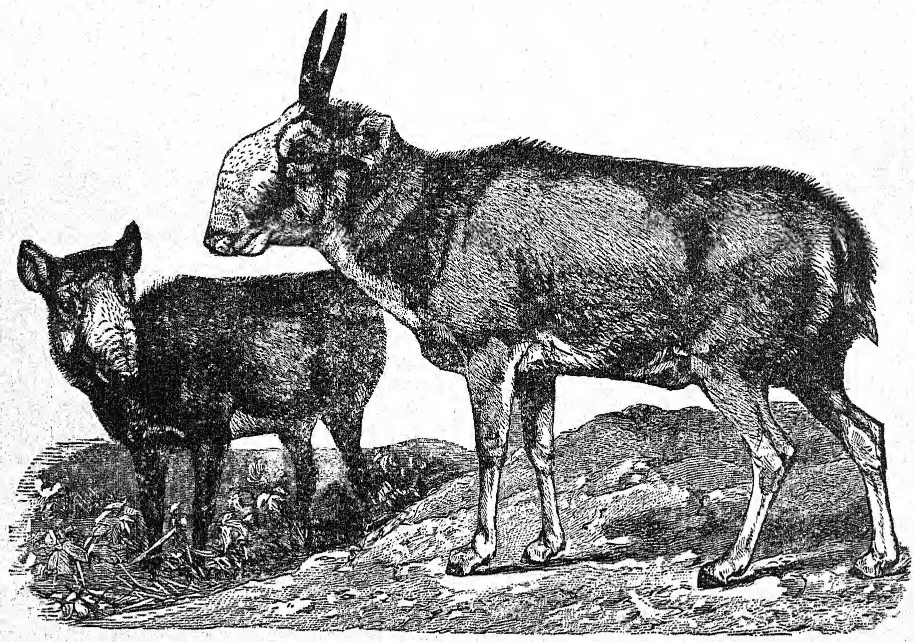


Fig. 80.—The Saiga Antelope (*Colus Tartaricus*)

talized by various poets. The Dorcas Gazelle (*Gazella dorcas*), which inhabits North Africa, Syria, and Asia Minor, is perhaps the best-known kind. Other species are the Persian Gazelle (*G. subgutturosa*), the Indian Gazelle (*G. Bennetti*), and the Arabian Gazelle (*G. Arabica*).

Probably the most remarkable looking antelopes are the Saiga Antelope (*Colus Tartaricus*) and the Wildebeest or Gnu (*Catoblepas gnu*). The former, which looks as if it suffered from badly-swollen face (fig. 80), ranges from the steppes of Russia-in-Europe to the Altai Mountains. Apart from the Chamois it is the only European antelope. The Gnu (fig. 81) is an inhabitant of South Africa, and looks like a mixture of buffalo and horse, being endowed with the head of the one and the tail of the other.

5. The *Giraffe Family* includes the Okapi (*Okapia Johnstoni*, see vol. ii, p. 170), and the Giraffe (*Giraffa camelopardalis*). The latter is found in desert and semi-desert regions to the south of the Sahara. The more familiar South African variety (fig. 82) is marked with conspicuous brown blotches upon a tawny back-

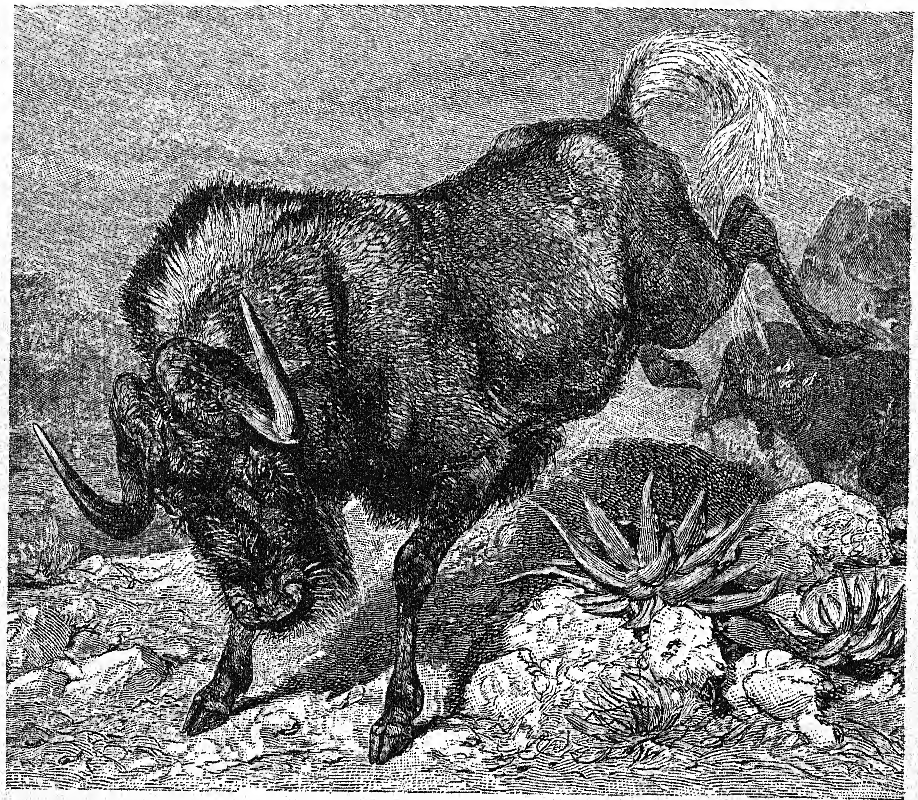


Fig. 81.—The Wildebeest or White-tailed Gnu (*Catoblepas gnu*)

ground, and this, suggesting the markings of a leopard, has given rise to the alternative name of Camelopard by which the animal is often known. In the variety living farther north the colours are reversed, so to speak, the background being brown, but the tawny hue is disposed not in patches but a close network of lines. Unfortunately, it appears to be one of the many species doomed to complete extinction at no distant date.

The giraffe rejoices in the distinction of being the tallest living mammal, adult bulls sometimes measuring as much 19 feet from the top of the head downwards. This unusual height is partly due to the great length of the neck, and partly to the relatively

greater height of the front part of the body. The head is decidedly graceful, the long tail is tufted, and there is no trace of accessory hoofs at the sides of the feet. As in sheep, &c., the upper incisors and canines are replaced by a horny pad. A very distinctive external feature consists in the possession of two short rounded horns, consisting of a bony core covered by soft skin. There is also a rounded skin-covered knob between the eyes.

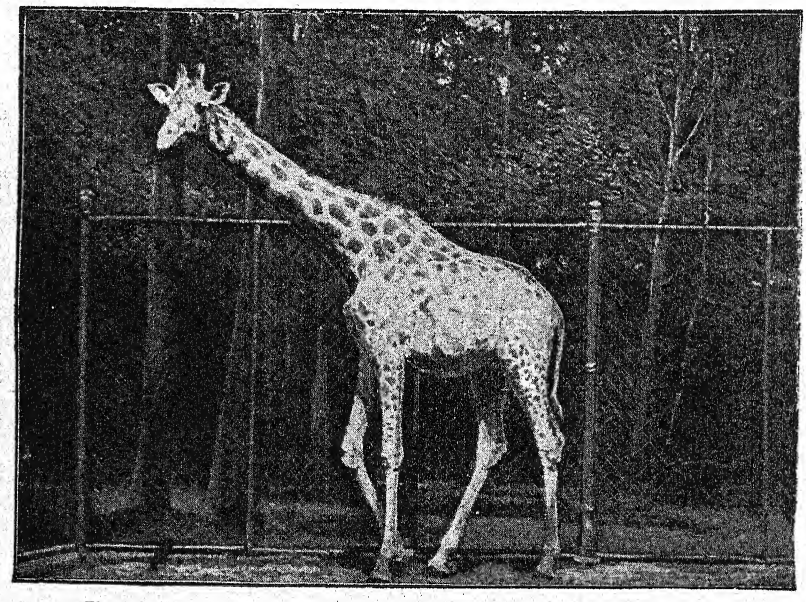


Fig. 82.—The Giraffe (*Giraffa camelopardalis*). (From an instantaneous photograph)

The protrusible tongue is extremely flexible, and serves as a grasping organ for seizing the twigs of trees.

6. The *Camel Family* is the last to be mentioned under the heading of Ruminants. The head is devoid of horns and placed at the end of a long curved neck. The limbs are elongated, and each of them terminates in two toes only, while the hoofs are replaced by pad-like swellings on the under side of the foot. Further characteristics are the split upper lip, incisors in the upper jaw, and well-developed canines both above and below. The family includes the camels of the Old World, and the llamas, with allied forms, in the New World.

Camels, which are now unknown as wild animals, though admittedly invaluable domestic forms, are decidedly ugly if measured by our standards of good looks; nor do they make up by amiability

what they lack in beauty. Kipling's faithful delineation of the "gawd-forsaken oont" is too well known to need quotation, but the following vivid account of the purchase of a camel given by Conan Doyle (*Daily News* of April 21, 1896) is probably less familiar.

"There are camels to be bought, and it is a study in Eastern ways to see the *Daily News* buying them. Some men have the gift of pantomime, and some have not. I know by experience that I have not. On the occasion of an eclipse of the moon I endeavoured to explain the cause of it by gesture to an Arab. I pointed to the moon and to the earth. Then I pointed to a horse and to his shadow. Presently the Arab rose and began to examine the horse's hind-legs, and I found that I had convinced him that the creature was ill. I have given up gestures since then. But the *Daily News* has all the Arab's energy of movement, with a good command of abuse, and some powers as a pedestrian. With these gifts, one may buy camels.

"Having looked depreciatingly at the beast—and you cannot take a better model than the creature's own expression as it looks at you—you ask how much is wanted for it. The owner says sixteen pounds. You then give a shriek of derision, sweep your arm across as if to wave him and his camel out of your sight for ever, and, turning with a whisk, you set off rapidly in the other direction. How far you go depends upon the price asked. If it is really very high, you may not get back for your dinner. But as a rule, a hundred yards or so meet the case, and you shape your course so as to reach the camel and its owner. You stop in front of them and look at them with a disinterested and surprised expression, to intimate that you wonder that they should still be loitering there. The Arab asks how much you will give. You answer eight pounds. Then it is his turn to scream, whisk round, and do his hundred yards, his absurd chattel with his hornpipe legs trotting along behind him. But he returns to say that he will take fourteen, and off you go again with a howl and a wave. So the bargaining goes on, the circles continually shortening, until you have settled upon the middle price. But it is only when you have bought your camel that your troubles begin. It is the strangest and most deceptive creature in the world. Its appearance is so staid and respectable that you cannot give it credit for the black villainy that lurks within. It approaches you with

a mildly interested but superior expression, like a patrician lady in a Sunday-school. You feel that a pair of glasses at the end of a fan is the one thing lacking. Then it puts its lips gently forward, with a far-away look in its eyes, and you have just time to say 'The pretty dear is going to kiss me', when two rows of frightful green teeth clash in front of you, and you give such a backward jump as you could never have hoped at your age to accomplish. When once the veil is dropped, anything more demoniacal than the face of a camel cannot be conceived. No kindness and no length of ownership seems to make them friendly. And yet you must make allowances for a creature which can carry 600 lbs. for twenty miles a day, and ask for no water and little food at the end of it."

The Arabian Camel (*Camelus dromedarius*) is the common one-humped form of Africa and Asia, while the two-humped Bactrian Camel (*C. bactrianus*), a smaller animal, is characteristic of the desert regions of Central Asia.

The American members of the Camel Family consist of two wild species, conveniently grouped under the head of *Llamas*, a term also including the two domesticated forms. These animals are smaller than camels and more gracefully built; they are also devoid of a hump. The ears are pointed and comparatively long, instead of being short and rounded, the tail is very short, and the feet are relatively small as compared with the camel.

Of the two wild species the animal known as the Guanaco (*Lama guanacus*) is larger and more heavily built. It ranges from the mountains of Ecuador southwards to Tierra del Fuego. It is probably from this species that the two domestic forms, known as the Llama (*L. lama*) and the Alpaca (*L. pacos*), are descended.

The second wild species is the comparatively small and graceful Vicunia (*L. vicunia*), which ranges through the mountains of South America from Bolivia to Ecuador.

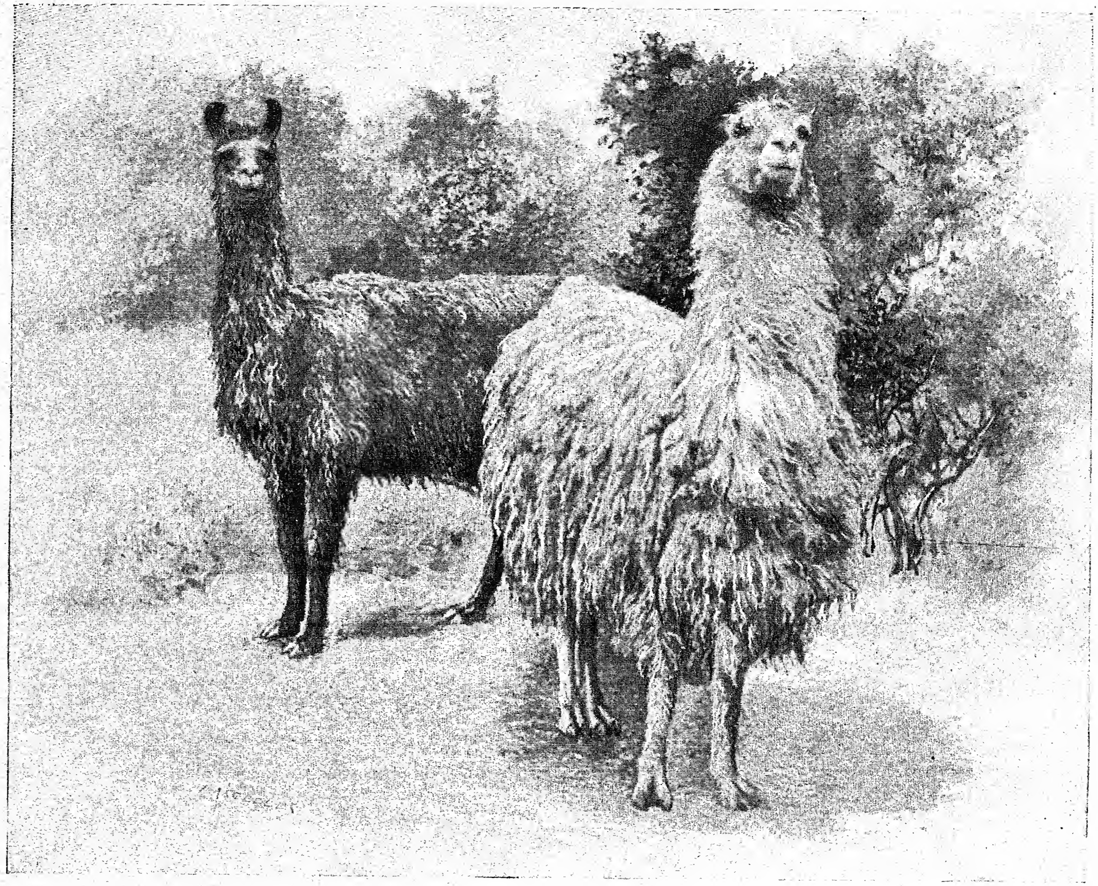
Order 11.—Gnawers (Rodentia)

This widely-distributed order includes a larger number of forms than any other, all of which feed largely, and the majority entirely, upon vegetable food. The largest species does not exceed the size of a small pig, while some are extremely small. Most of

THE LLAMA (*Lama lama*)

This animal was domesticated in very remote times by the ancient Peruvians, and even now is an important beast of burden in the high Andes of Peru and Bolivia, though the original breed has been replaced to a great extent by domesticated forms introduced from the Old World. In former times it was used in great numbers for the transport of silver ore from the famous mines of Potosi in Bolivia, more than 13,000 feet above the sea.

The Llama may be described as an American cousin of the Camel, belonging, as it does, to the same group (*Tylopoda*) of Ruminants or Cud-chewers. The earliest known members of this group were, however, native to North America, from which area the stock spread on the one hand into South America, and on the other into the Old World, having since become extinct elsewhere.



PERUVIAN LLAMAS (LAMA LAMA)

A STUDY FROM THE LIFE

them live upon the surface of the ground, but some burrow and some climb, while others have taken to the water. The general organization is of rather a low type, but there is much specialization in the most characteristic structures, *i. e.* the teeth. Rodents walk entirely or partly upon the soles of the feet, and the digits are usually provided with claws, though more rarely they possess small hoofs. The most striking feature regarding the teeth is the character of the incisors, of which in the adult never more than four are developed to a useful extent. These are large chisel-ended structures, growing continuously throughout life, as they are worn away by the constant gnawing which is so characteristic of the order. This is strikingly seen in the cases of unfortunate animals which have lost one incisor, as a result of which the corresponding tooth has nothing to bite against, and not being therefore subjected to wear, grows to an enormous length, ultimately killing its unlucky owner. A similar state of things may result from malformation or accident, if thereby the upper and lower teeth are prevented from coming together. Canine teeth are always absent, and the cheek teeth are commonly reduced in number, and more or less adapted to act as grinders. There is an interesting feature, already alluded to (p. 28), regarding the jaw-joint, which permits of the free backward-and-forward movement necessary for gnawing. This is due to the fact that the condyles of the lower jaw are elongated from front to back, and fit into sockets of corresponding shape.

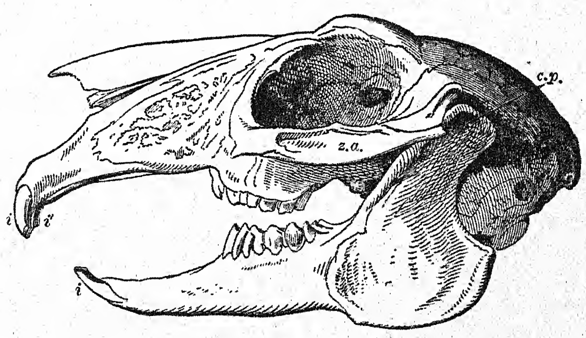


Fig. 83.—Skull of Hare. Observe the small upper incisors *i'* behind the large functional ones *i*; *c.p.* coronoid process; *z.a.* zygomatic arch.

There are four great groups of existing Rodents, which may broadly be called: 1. Rabbits; 2. Squirrels; 3. Mice; and 4. Porcupines.

1. The group of Rabbits, including also Hares and Pikas, is distinguished by the presence of two small upper incisor teeth, situated immediately behind the two large teeth of the same kind present here as in all Rodents (fig. 83). It may also be added that the two bones of the lower

leg (tibia and fibula) are united together at their lower ends. Three animals common in Britain may be taken as illustrations, *i.e.* the Rabbit, Hare, and Alpine Hare.

The Rabbit (*Lepus cuniculus*) (fig. 84), though so common in the British area, is believed not to be indigenous, and the same may be said of many other countries where it now abounds. Its

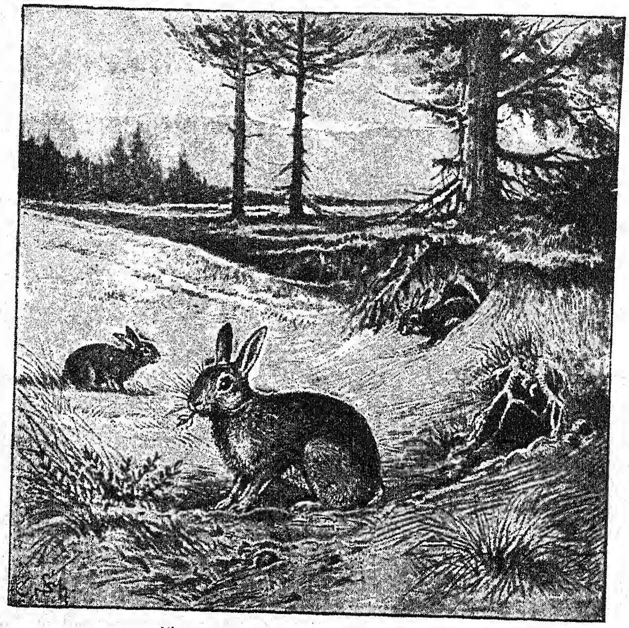


Fig. 84.—The Rabbit (*Lepus cuniculus*)

original home was probably in the area adjoining either shore of the western Mediterranean. Marked characteristics are gregariousness, burrowing habits, and the immature state in which the young are born. The Hare (*L. timidus*) is a larger animal which is not gregarious and does not burrow, while the newly-born leverets can see, and are scantily clad with fur. The black-tipped ears and very long hind-limbs are also noticeable features. Absent from Ireland, Scandinavia, and North Russia, the hare has a wide distribution over the rest of Europe from Great Britain to the Caucasus. The Alpine Hare (*L. variabilis*) assumes a white or light-coloured winter coat. In the British area it is found in Scotland and the northern parts of England, while it replaces the common species in Ireland. From our islands it ranges across the northern part of the Old World to

Japan, and also from the Pyrenees to the Caucasus. Other species of hare are found in various parts of Asia, Africa, North America, and South America.

Pikas, or *Calling Hares*, are small creatures somewhat resembling guinea-pigs, apparently devoid of tail, and with rounded ears of small dimensions. They are gregarious, and, failing fissures in the rocks, excavate burrows. Most of the species inhabit the north and central parts of Asia, one of these, the Siberian Pika (*Lagomys Alpinus*) (fig. 85), ranging into Eastern Europe. There is also one species in North America.

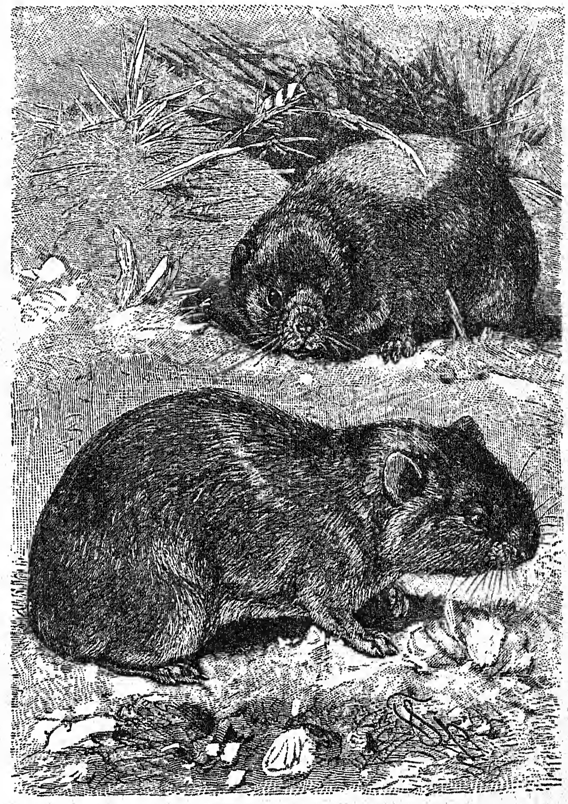


Fig. 85.—The Siberian Pika (*Lagomys Alpinus*)

The three remaining groups of Rodents—Squirrels, Mice, and Porcupines—agree with one another, and differ from rabbits and their allies, in the number of the incisor teeth, these being only four in number, two above and two below.

2. The SQUIRRELS include forms in which the bones of the lower leg (tibia and fibula) are not united together. Squirrels, Marmots, and Beavers are the representative types.

SQUIRRELS, as well seen in the Common Squirrel (*Sciurus vulgaris*), our native species, have a rounded head, from which large tufted ears project, a large bushy tail, and extremities provided with sharp claws. The thumb is of very small size. The range of this species includes the greater part of Europe, North and Central Asia, and North Africa. Squirrels of one sort or another are found in almost all hot and temperate countries, Madagascar and Australia excepted. *Ground-Squirrels*,

which, as the name indicates, live upon the ground, are common in the colder parts of the northern hemisphere. Much resembling ordinary squirrels in appearance, they differ in the smaller size of the tail, the absence of tufts to the ears, and the possession of large cheek-pouches. They excavate burrows in the ground. The Common Chipmunk (*Tamias striata*) of North America is a good example. *Flying-Squirrels* possess a parachute-like fold of skin on either side, much as in the Flying-Lemur (cp. p. 86). They mostly range from India to Japan, but are also represented in North America, Siberia, and East Europe. The Brown Flying-Squirrel (*Pteromys petaurista*) is the largest species. The African Flying-Squirrels (*Anomalurus*), mostly natives of West Africa, differ from the preceding chiefly in the structure of the tail and flying-membrane.

Fig. 86.—The Common Suslik (*Spermophilus citillus*)

Least squirrel-like of the squirrel sub-group are the *Susliks* or *Gophers*, found in much the same regions as the ground-squirrels. They are burrowing forms with large cheek-pouches. The Common Suslik (*Spermophilus citillus*), which ranges from Central Europe to Siberia, has a short tail and very small ears (fig. 86). The Striped Gopher (*S. tridecemlineatus*) of North America is somewhat better off as regards ears and tail, and is prettily marked with stripes and rows of dots.

Marmots are more stoutly built than squirrels, their ears being smaller and their tails shorter, while cheek-pouches are present. They are burrowing social forms, and their area of distribution includes the colder parts of the northern hemisphere. A familiar European type is the Alpine Marmot (*Arctomys marmotta*) of the Pyrenees, Alps, and Carpathians. A common North American form is the Woodchuck (*Arctomys monax*).

The *Prairie Marmots* of North America are closely related to the preceding. The best-known species is the Common Prairie Marmot, often called "prairie-dog" (*Cynomys ludovicianus*), large

numbers of which inhabit the plains on the east of the Rocky Mountains (fig. 87).

BEAVERS are comparatively large Rodents which spend a large part of their time in the water and are modified accordingly, the hind-feet being webbed, and the rudder-like tail flattened and scaly. There are only two living species, one in Eurasia and the other in North America. The former, or European Beaver

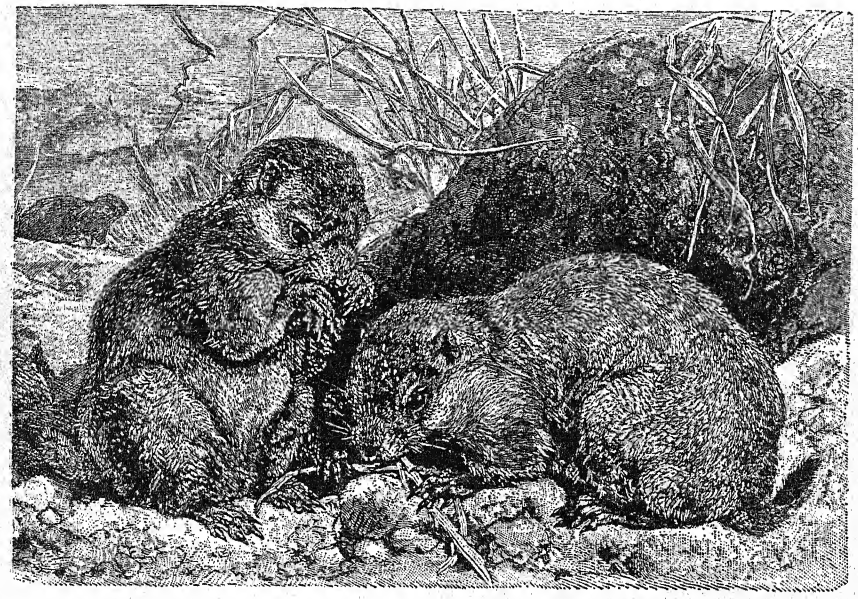


Fig. 87.—Prairie-Dogs (*Cynomys Ludovicianus*)

(*Castor fiber*), at present ranges from France to Siberia, but was once distributed much more widely, and in remoter times was a member of the British fauna, as attested by numerous remains. The American Beaver (*Castor Canadensis*) is now practically limited to Canada, though it once extended over the greater part of North America.

3. MICE include a very large number of species, and are represented in all parts of the world. A characteristic anatomical feature is found in the union of the two bones of the lower leg (tibia and fibula). The group includes the following families:—(1) Mice and Rats; (2) Mole-Rats; (3) Pouched Rats; (4) Jumping-Mice; and (5) Dormice.

(1) The *Mouse and Rat Family* includes more species than the others, and unlike them is cosmopolitan, being represented

even in Australia, from which all the other groups are absent. The tail is bare and scaly, the incisor teeth narrow, and the fore- and hind-limbs of about the same length. The thumb is much reduced. No less than eight species are found in Britain including rats, mice, and voles. The largest of these is the Common or Brown Rat (*Mus decumanus*), which, like all members of the same genus, has a long tail, and projecting tubercles on the crowns of the grinding teeth. It is supposed to have been introduced in the year 1730, and has largely ousted the smaller Black Rat (*M. rattus*), which is also an introduced form, though the date of its first arrival was much more remote. The most familiar of our mice is the House-Mouse (*M. musculus*), distinguished by the large size of its delicate ears. The Wood-Mouse, also called the Long-tailed Field-Mouse (*M. sylvaticus*), is very similar in appearance, but can be distinguished by its white under-surface. The little Harvest-Mouse (*M. minutus*), the nests of which are often found suspended from corn-stalks, is the most diminutive of our native mammals, the smallest shrew alone excepted. *Voles*, of which three species are native to Britain (but not Ireland), are distinguished from rats and mice by their clumsier proportions, shorter limbs and tail, and blunter snouts. They feed entirely upon vegetable matter, their back teeth being adapted to this kind of food, and having crowns of peculiar

Fig. 88.—The Water-Vole (*Microtus amphibius*)

pattern, suggesting a double series of opposed triangles alternating with one another. The largest of our three species is the Water-Vole (*Microtus amphibius*), often miscalled the Water "Rat". It is brown in colour and about the same size as an ordinary brown rat (fig. 88). The Bank-Vole (*M. glareolus*) is less stoutly built, with redder fur and longer tail. Much smaller and more abundant than these two species is the Field-Vole (*M. agrestis*), which sometimes multiplies to such an extent as to become a serious agricultural pest. It is often called the Short-tailed Field-Mouse, but is at once distinguished from a mouse by its shorter tail, and by the other features already enumerated as characteristic of voles generally.

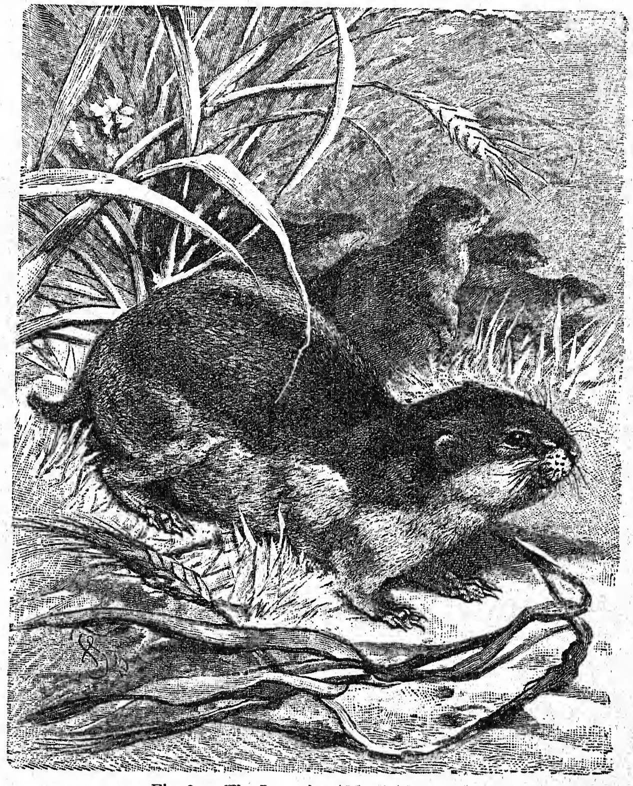


Fig. 89.—The Lemming (*Myodes lemmus*)

Other examples of the Mouse family are afforded by the *Hamsters*, *Lemmings*, and *Musquashes*. The Common Hamster (*Cricetus frumentarius*) of Europe and North Asia is a comparatively large rodent, being as much as a foot in length inclusive of the short tail, the abbreviated nature of which at once shows that the creature is not a rat, which animal it otherwise somewhat resembles in external appearance. There are very large cheek-pouches. Hamsters are burrowing forms, and they store up large quantities of grain, seed, and other vegetable matter. They increase very rapidly in number and often do serious damage to crops. "A South American relative (*Ichthyomys*) of the Hamster lives in

streams, and feeds on fish. The edges of the upper incisors are slanted towards each other to give a Λ-shaped notch. This is an adaptation for holding the slippery prey."

Lemmings resemble voles in many respects, but their tails are even shorter, while their claws are better developed and the fur is much thicker. The best-known species is the Norwegian Lemming (*Myodes lemmus*) (fig. 89), which inhabits the mountain regions of Scandinavia, and from time to time migrates in vast numbers, travelling in a straight line despite all obstacles, and ultimately plunging into the sea, where it soon perishes, as might be anticipated.

Fig. 90.—Kangaroo-Rat (*Dipodomys Phillipsi*)

The Musquash or Musk-Rat (*Fiber zibethicus*), which has a wide range in North America, may be regarded as a very large vole, thoroughly adapted to an aquatic life, as may be seen by its partly-webbed feet and strong flattened tail. It is largely hunted for the sake of its fur.

(2) The *Mole-Rat Family* includes Old World rodents which have taken to a burrowing life, with the result that their structure has undergone modifications of much the same kind as those exemplified by ordinary moles. A typical species is the Great Mole-Rat (*Spalax typhlus*), the range of which includes South-east Europe, South-west Asia, and lower Egypt.

(3) The North American *Pouched-Rat Family* includes a

number of forms which, though they differ greatly among themselves in appearance, all possess large hair-lined cheek-pouches. The Common Pocket-Gopher (*Geomys bursarius*) looks something like a compromise between a rat and a mole. It is a burrowing form inhabiting the central plains watered by the Mississippi and its tributaries. The Common Kangaroo-Rat (*Dipodomys Phillipsi*) is a desert animal with long hind-limbs and tail (fig. 90), enabling it to adopt the mode of progression characteristic of the kangaroo. The Banded Pocket-Mouse (*Perognathus fasciatus*) of the States resembles the last-named form on a small scale.

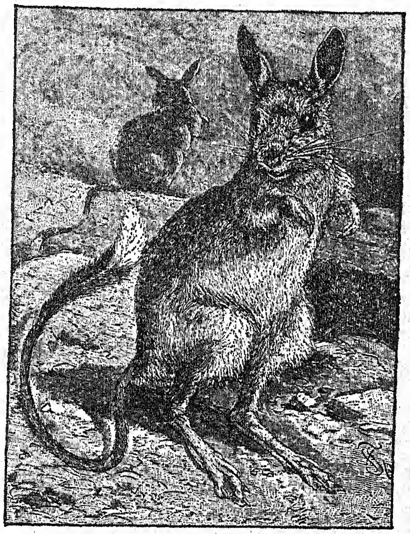


Fig. 91.—The Jerboa (*Alactaga decumana*)

(4) The *Jumping-Mouse* or *Jerboa Family* includes species which, like the Kangaroo-Rat and Pocket-Mouse of the last family, are specialized in relation to a springing mode of progression. They are, however, devoid of cheek-pouches. The species are chiefly found in Africa and Asia, though the family is also represented in South Europe and North America. A good illustrative species is the Siberian Jerboa (*Alactaga decumana*) (fig. 91).

(5) The *Dormouse Family* embraces small mouse-like animals which have adopted an arboreal life, and in some respects have become specialized in much the same way as squirrels. Species are found in Europe, Asia, and Africa, and there is one British form, the Common Dormouse (*Muscardinus avellanarius*), abundant in the south of England, but absent from Ireland and the northern part of Great Britain (fig. 92).

4. The Porcupine group of Rodents takes in a large number of forms, of which one common character is the separateness of the two bones (tibia and fibula) of the lower leg. The group is predominatingly American, and specially characteristic of South America. The following five families are included:—(1) Octodons; (2) Porcupines; (3) Chinchillas; (4) Agoutis; and (5) Cavies.

(1) *Octodons* are somewhat rat-like forms mostly found in

South America, but also represented in the West Indies and in Africa. A typical form is the Degu (*Octodon degus*) of Peru and Chili (fig. 93). The enamel folds on the crowns of the grinding teeth have a characteristic figure-of-eight pattern.

Fig. 92.—The Common Dormouse (*Muscardinus avellanarius*)

(2) The *Porcupine Family*, distinguished by the possession of quills, is very widely distributed, Australia being the only continent from which its members are absent. All the Old World forms live on the ground, as is, for example, the case with the Common Porcupine (*Hystrix cristata*), which inhabits the Mediterranean countries, though comparatively scarce in those of them which are European. The Brush-tailed Porcupine (*Atherura Africana*) of West and Central Africa looks like a spiny rat. The New World forms are distinguished by being climbers. A common example is the Canadian Porcupine (*Erethizon dorsatus*).

None of the remaining families of the Porcupine group are

found outside South America, Central America, and the West Indies.

(3) The family made up of the *Chinchillas* and their allies is distinguished by the soft fur, well-developed tail, elongated hind-legs, and transversely-ridged crowns to the grinding teeth. The Common Chinchilla (*Chinchilla lanigera*) (fig. 94), a valuable

Fig. 93.—The Degu (*Octodon degus*)

fur-bearing animal inhabiting the mountains of Chili and Bolivia, is a very active squirrel-like creature in which there are five toes on the fore- and four toes on the hind-foot. The allied Viscacha (*Lagostomus trichodactylus*) is a stoutly-built burrowing form, of which the communities are common in the pampas of South America.

(4) The *Agoutis* and *Pacas* together constitute a South American family of which the members attain a considerable size. The claws are blunt and hoof-like. The short-tailed Common Agouti (*Dasyprocta agouti*) inhabits the forest regions of South America, and the tailless Paca (*Cœlogenys paca*), distinguished

by the presence of five rows of yellow spots on the fur, has a wide range through the same continent, east of the Andes and to as far south as Paraguay. It is also a native of the islands of Trinadad and Tobago.

(5) The family of *Cavies* resembles the preceding in the hoof-like nature of the claws, and are further characterized by the

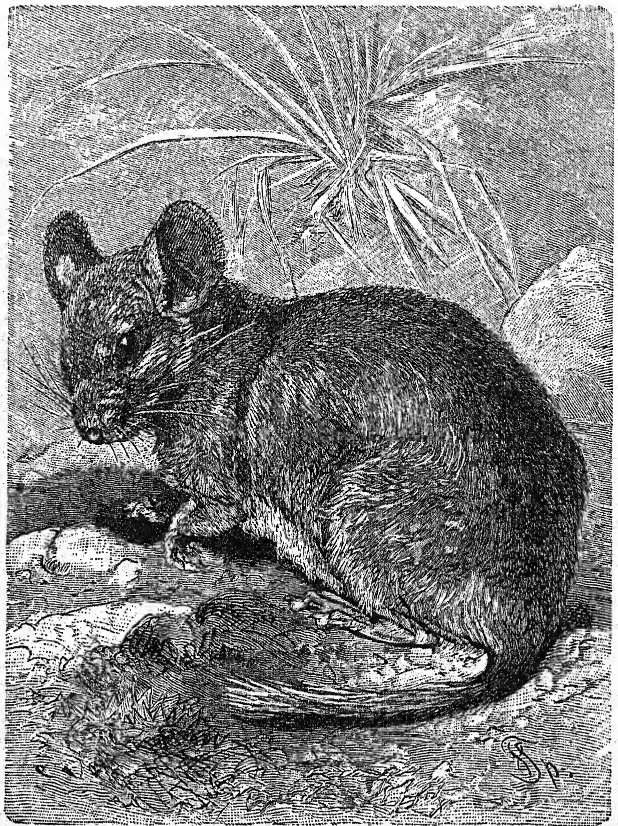


Fig. 94.—The Common Chinchilla (*Chinchilla lanigera*)

extreme brevity of the tail. The grinding teeth are complex, and their crowns present numerous transverse ridges. A common example is the domestic Guinea-Pig (? *Guiana pig*), introduced into Europe in the sixteenth century. The Restless Cavy (*Cavius porcellus*) of Uruguay and Brazil has been claimed as the ancestral stock, though the view is now held that this distinction rests with Cutler's Cavy (*Cavia Cutleri*), a Peruvian form supposed to have been domesticated by the Incas. The largest known Rodent, the Capybara (*Hydrochærus capybara*), is simply

an exaggerated Cavy specialized for an aquatic life, as testified by its webbed feet. It inhabits the great rivers of South America, and is not unlike a small pig in general appearance and

Fig. 95.—The Unau or Two-toed Sloth (*Cholœpus didactylus*)

size. The writer well remembers seeing a tame specimen, which had escaped from the grounds of its owner and swum down the Teign estuary to Teignmouth, being exhibited in the lifeboat-house there as "a pigfacious hippopotamus".

Order 12.—Edentates (Edentata)

This very remarkable group includes a number of both Old and New World forms, which are rather low in the scale, and have had to adopt various expedients in order to avoid being exterminated by the active competition of more highly organized forms. It is very doubtful whether the Old World forms have any special relation to the New World ones, or in other words the order is a very artificial one. This comes out strikingly when an attempt is made to discover common characters. About all that can be said is, that the teeth are highly peculiar in character, and that the digits are provided with curiously modified curved hoofs. As to the former structures the term "edentate", *i.e.* toothless, is somewhat misleading, for though this is the case with some forms, it is not generally true, though the front teeth are always more or less deficient. A further point is that the teeth are always devoid of enamel.

Most of the Edentates are found only in South America, and of these the following are representative species:—The Two-toed Sloth (*Cholœpus didactylus*) (fig. 95) of Guiana and Surinam; the Six-banded Armadillo (*Dasypus sexcinctus*) (fig. 96) of the South American pampas; and the Ant-Bear (*Myrmecophaga jubata*) of Paraguay. Old World forms are: The Cape Ant-Eater or Aard-Vark (*Orycteropus Capensis*) (fig. 97) of South Africa, and the Long-tailed Pangolin (*Manis pentadactyla*) (fig. 98) of West Africa.

Order 13.—Pouched Mammals (Marsupialia)

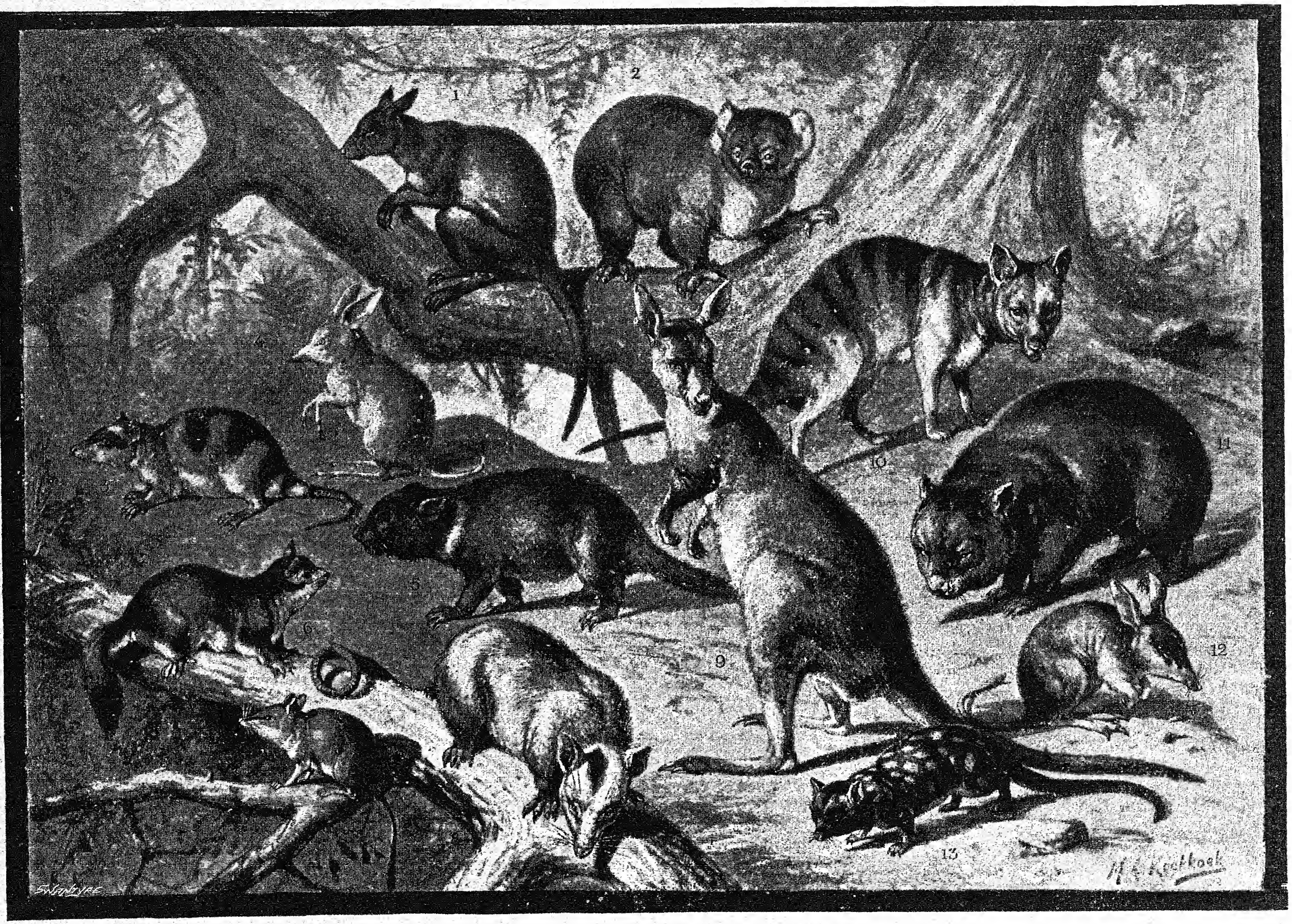
This is the only order in the Mammalian sub-class Metatheria, under which heading its leading characters have already been given (p. 68).

The great bulk of existing Marsupials are confined to Australia and its adjacent islands, as far as Celebes, though the order is also represented in America. The great interest attached to the Australian forms is found in the way they have become specialized in various directions to fill the most varying places in the economy of nature. Other more highly organized mammals having been absent, they have had the field to themselves without other serious competition, and the places occupied in most parts of the world

POUCHED MAMMALS (*Marsupialia*)

1. Tree-Kangaroo of New Guinea (*Dendrolagus ursinus*).
2. Koala (*Phascolarctos cinereus*).
3. Water Opossum (*Chironectes minima*).
4. Pig-footed Bandicoot (*Chœropus castanotis*).
5. Tasmanian Devil (*Sarcophilus ursinus*).
6. Squirrel-like Flying Phalanger (*Petaurus sciureus*).
7. Jerboa Pouched-mouse (*Antechinomys laniger*).
8. Philander Opossum (*Didelphys philander*).
9. Great Grey Kangaroo (*Macropus giganteus*).
10. Tasmanian Wolf (*Thylacinus cynocephalus*).
11. Hairy-nosed Wombat (*Phascolomys latifrons*).
12. Gunn's Bandicoot (*Perameles Gunni*).
13. Common Dasyure (*Dasyurus viverrinus*).

Numbers 3 and 8 are American forms, the remainder belong to the Australian region.



GROUP OF POUCHED MAMMALS (MARSUPIALIA)

Numbers 3 and 8 are American forms, the remainder belong to the Australian region

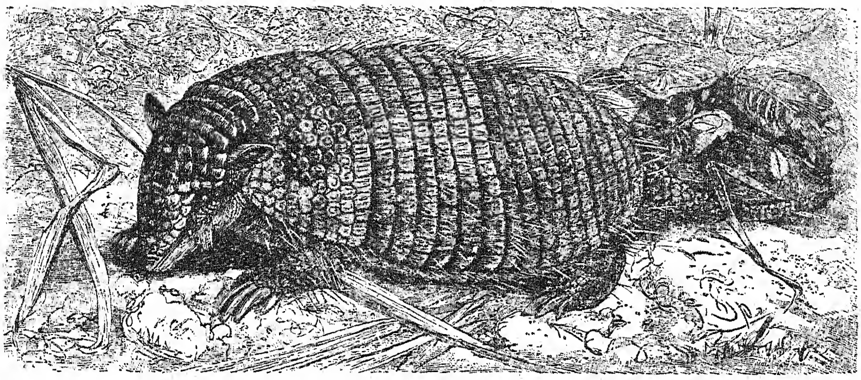


Fig. 96.—The Six-banded Armadillo or Poyou (*Dasypus sexcinctus*)

by such groups as Carnivora, Insectivora, &c., are here filled by marsupial sub-orders.

The American marsupials have had to compete with forms

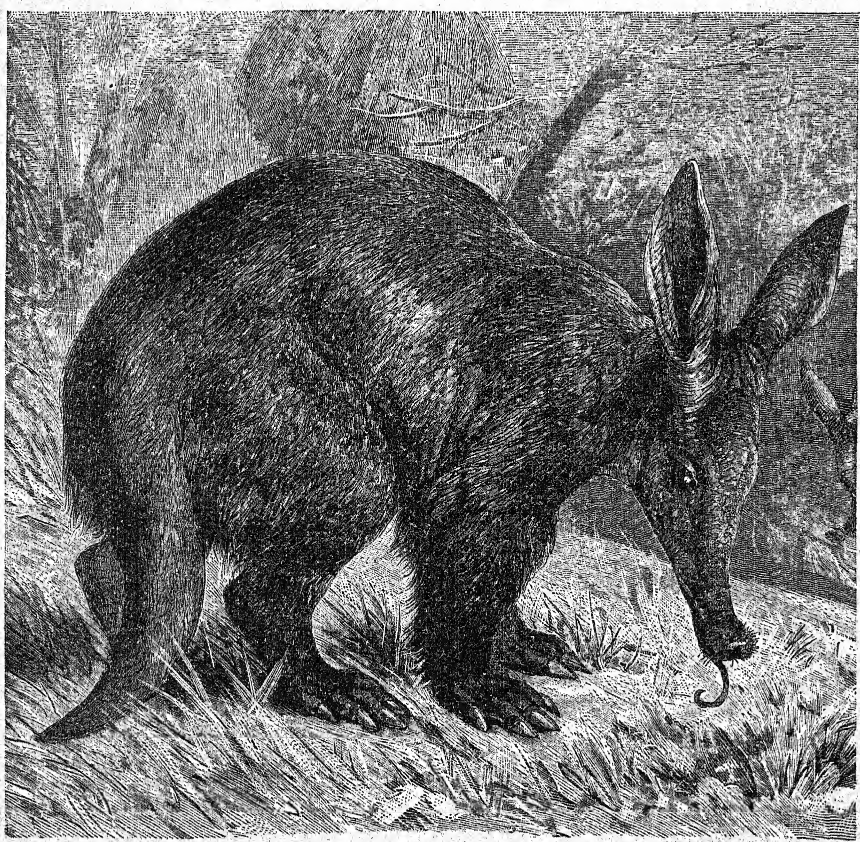


Fig. 97.—The Aard-Vark or Cape Ant-Eater (*Orycteropus Capensis*)

better adapted to struggle for existence, and play but a subordinate part in the fauna of that continent. They consist of the Opossums, found both in North and South America, and of a small creature Cœnolestes recently discovered in the latter continent. The Common Opossum (*Didelphys Virginiana*) has

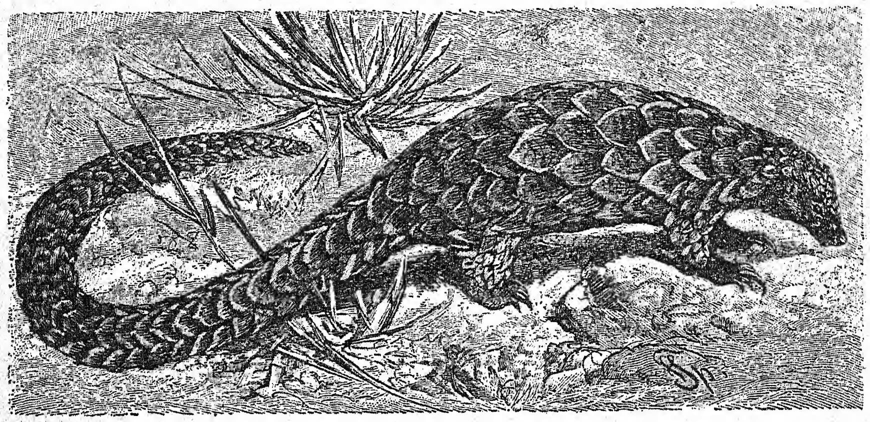


Fig. 98.—The Long-tailed Pangolin (*Manis pentadactyla*)

a wide distribution in North America, from Canada to Mexico. It is the well-known "'possum" of American story and verse.

Order 14.—Egg-laying Mammals (Monotremata)

Like the preceding one, this order is the only one in its subclass (Prototheria), of which the leading characters have already been given (p. 69). It will suffice to remark here that its members are only found in the Australian region, like the majority of Marsupials, and having had to compete with these comparatively more powerful forms, have been prevented from occupying more than a subordinate position in the fauna of that region.

CHAPTER III

STRUCTURE AND CLASSIFICATION OF BIRDS

Though Birds are familiar objects to all, and obviously characterized by the possession of wings and feathers, these are not the only essential features distinguishing them, and it will clear the ground to briefly describe some well-known and typical example of the class. This is the better worth doing since the great bulk of existing birds resemble one another to a much greater extent than is the case with mammals.

As convenient a type as any, and one possessing special interest from the fact that Darwin devoted a very large amount of attention to it from the evolutionary stand-point, is the Pigeon (*Columba livia*). Of this there are a large number of domestic varieties, some very peculiar in appearance, but for our purpose the best is the one known to fanciers as the "Blue Rock", which best represents the central form from which the different varieties have sprung, and which is found wild in Europe, North Africa, and West Asia as far as India.

The wild Blue Rock nests in caves or clefts of the rock, and is of common occurrence round the northern coasts of Ireland and Scotland. Its prevailing hue is grey, but the rump is white, and the neck and upper part of the breast green and purple, with a metallic sheen. There is a characteristic broad black bar running across the end of the tail, while the wing is crossed by two similar but narrower bands.

External Characters (fig. 99).—The outlines of a bird are mainly determined by the feathers, as is strikingly seen on comparing a living bird with a plucked specimen, the latter presenting a very comical appearance. The head is well rounded behind, in correspondence with the presence of a large brain, while the face is produced in front into a somewhat conical horny beak, at the base of which are situated the two slit-like nostrils, over-

hung by a bare patch of swollen skin, the *cere*. The large eyes are provided not only with upper and lower eyelids, but also with a translucent *nictitating* membrane, or third eyelid, which can be rapidly twitched over the front of the eye by special muscles. A narrow bare area of skin surrounds each eye, and in such breeds as the Carrier, this area and the cere are highly developed into peculiar fleshy outgrowths. Below and behind the eye is the

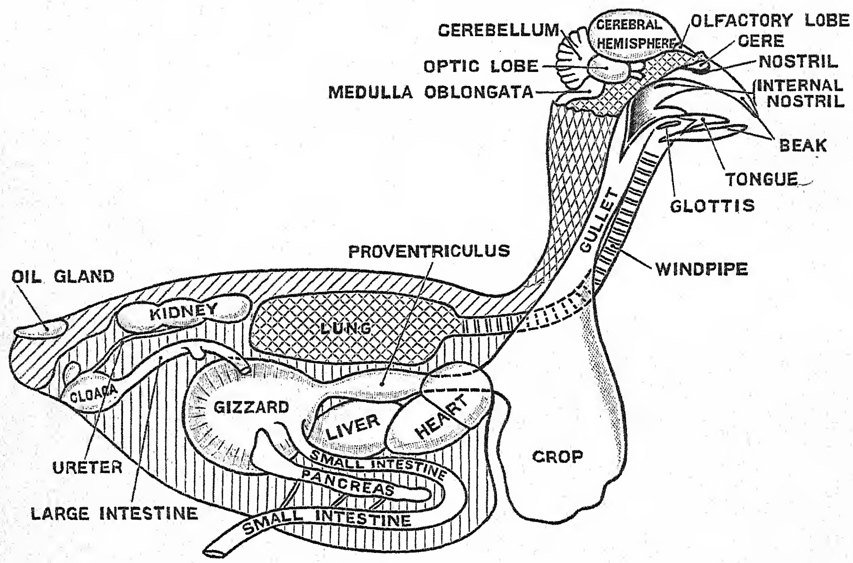


Fig. 99.—General Structure of Pigeon

small round auditory aperture, which is not provided with a pinna as in most mammals.

The long and exceedingly mobile neck is sharply marked off from the stout boat-shaped trunk, which is terminated by a stumpy tail, on the upper surface of which is a prominent papilla carrying the aperture of the large oil-gland. On the under side of the trunk, near its hinder end, is the opening of the cloaca, a small chamber into which open the intestine, the kidney-ducts, and the ducts of the reproductive organs.

The body of a bird exhibits innumerable adaptations to an aerial life, and this is seen very strikingly in the fore-limbs, which are modified into wings, quite different, however, in structure from those of a bat (see p. 81). The same sections are present as in a mammal, *i.e.* upper arm, fore-arm, and hand, but there are considerable differences in detail. In so far as folds of skin

connect upper arm and fore-arm in front, and upper arm and trunk behind, there is a certain resemblance to the bat's wing, but we do not find in the bird long slender fingers supporting a well-developed membrane, but a reduced hand possessing only three modified digits. The efficient part of the wing consists of feathers, and the limb is specialized so as to serve as a firm support for these.

When a bird is not flying it is supported by the hind-limbs, but the problem of bipedal progression is not solved here in the same way as in a human being (see p. 66), where the trunk is raised into a vertical position and brought into the same line as the legs. The hind-limbs of a bird are, as it were, shifted forwards so that the body is balanced somewhat obliquely between them. There are, however, some forms, such as Penguins (fig. 127), in which the trunk is raised into an approximately upright position, but even then the resemblance to the attitude of an erect human being is remote, for not only is the thigh attached as in other birds, but it points slantingly upwards instead of being directed downwards. It would not indeed be possible for a bird to completely straighten out its leg, for the thigh is more or less enclosed in the boundaries of the trunk, and is not entirely free, as in ourselves.

It is also noticeable that the regions of a bird's leg, with the exception of the uppermost one, or thigh, do not exactly correspond with the subdivisions found in a mammal. The other two sections may be called, for convenience, lower leg and foot, but the ankle-joint between them is not in exactly the same position as in the last-named group. This will be more fully explained in dealing with the endoskeleton. The digits are four in number, instead of five as in a typical mammal, the digit corresponding to the little toe of which being absent. The great toe is turned backwards, and, since the body is supported upon the digits while the metatarsus and tarsus are raised from the ground, the bird may be termed digitigrade.

Skin and Exoskeleton.—The thin skin is made up, as in a mammal, of epidermis and dermis, and the former gives rise to a well-marked exoskeleton, consisting of beak, claws, scales, and feathers. The *beak* comes under this heading in so far as the horny sheaths which cover both upper and lower jaws are concerned, while the toes are provided with *claws*, and the feet are

covered by overlapping *scales.* The characteristic parts of the skeleton, however, are the *feathers* (fig. 100), structures which are possessed by all birds, but by no other animals. They do not cover the entire surface of the body, but are limited to certain feather tracts (*pterylæ*), between which are bare patches (*apteria*). Feathers, like hairs, spring from pits in the skin, and are renewed from time to time, during a moulting season. They are of three kinds: 1. small downy *filoplumes*, consisting of a stalk with a tuft

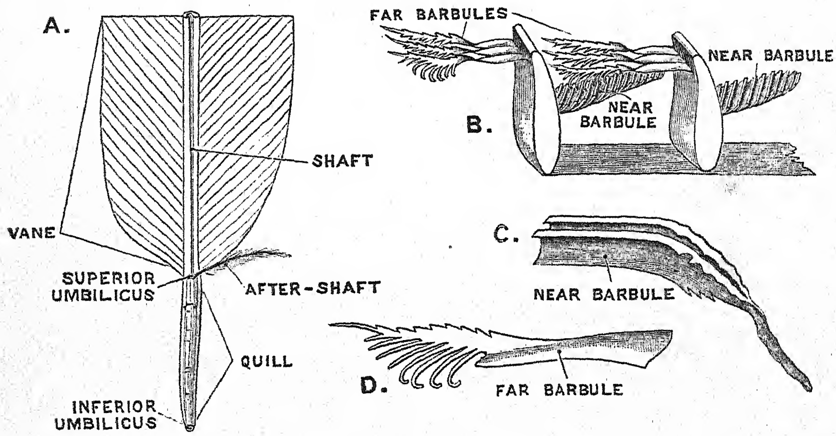


Fig. 100.—Structure of a Feather (there is no after-shaft in the Pigeon)
A, Base of quill-feather; B, barbs and barbules (much enlarged); C and D, separate barbules (still further enlarged).

of filaments at the end; 2. *contour* feathers, which cover most of the body, and, as the name indicates, determine its shape; and 3. large *quill-feathers* used in flight, and attached to the wings and tail. The last two kinds closely resemble one another in structure, and it may suffice to describe one of the quills, which are the most specialized and characteristic of feathers. Both light and strong, with a large surface for opposing to the air, they are exquisitely adapted to their purpose, even in the minutest details of their structure. We can distinguish between a central shaft, consisting of a hollow *quill* continued into a solid *rachis*, and oblique filaments or *barbs* projecting from each side of the rachis and constituting with it the *vane.* Each barb is provided with an oblique set of *barbules* on its far or distal side, facing the end of the feather, and a similar set on its near or proximal side, facing towards the base of the feather. The barbules of the distal row are provided with hooklets, which catch on to ridges possessed by the row of proximal barbules immediately in front of them.

Twenty-three quills (remiges) are attached to the hinder margin of each wing, eleven of them being *primaries* fixed to the hand, while the twelve others are *secondaries* borne by the fore-arm. The bases of these quills are covered above and below by other feathers known respectively as upper and lower *wing-coverts*. There is also a tuft of feathers, the *bastard wing* (ala spuria), upon the thumb.

Twelve *tail-quills* (rectrices) are attached in the form of a fan to the stumpy tail, and the bases of these are covered by upper and lower *tail-coverts*.

The *contour feathers*, including the coverts and the bastard wing, resemble quill-feathers on a small scale, but when they are plucked away a number of *filoplumes* are found among them, each consisting of a stalk bearing a loose tuft of barbules at its end. The *down-feathers* with which the nestling is covered closely resemble these.

Endoskeleton (fig. 101).—The same regions and parts can be recognized as in a mammal, but there are very considerable differences in detail, most, if not all, of which are related to the mode of life. The bones are particularly light and spongy, while many of them contain air instead of marrow, one of the arrangements whereby the specific gravity of the body is reduced as an adaptation to flight.

A number of features distinguish the *skull* from that of a mammal, one being that in the adult the bones are fused together so as to obliterate the junctions between them. This feature, however, is also seen in the lowest mammals, *i.e.* the Spiny Ant-Eater and Duck-billed Platypus, and is not the only point in which these creatures show a resemblance to birds. We have seen that at the back of a mammal's skull (p. 28) there are two rounded occipital condyles which fit into corresponding cups in the first joint of the backbone, but in the pigeon only one such condyle is to be seen, and as a result of this the head can be turned very freely about from side to side. There is also a remarkable peculiarity in the attachment of the lower jaw to the skull, as this takes place by the intervention of a special bone, the *quadrate*, there being thus a double jaw joint, permitting the mouth to be opened very widely, a capacity which must have struck anyone who has ever examined a nest of young pigeons, sparrows, or canaries. It may also be noted in a young skull that each half

of the lower jaw is made up of several pieces instead of only one as in a mammal.

The *backbone* is very long and there are remarkable contrasts between its several regions, for whereas the neck vertebræ are united together by saddle-shaped surfaces so as to give extraordinary flexibility, the vertebræ of the trunk are largely fused

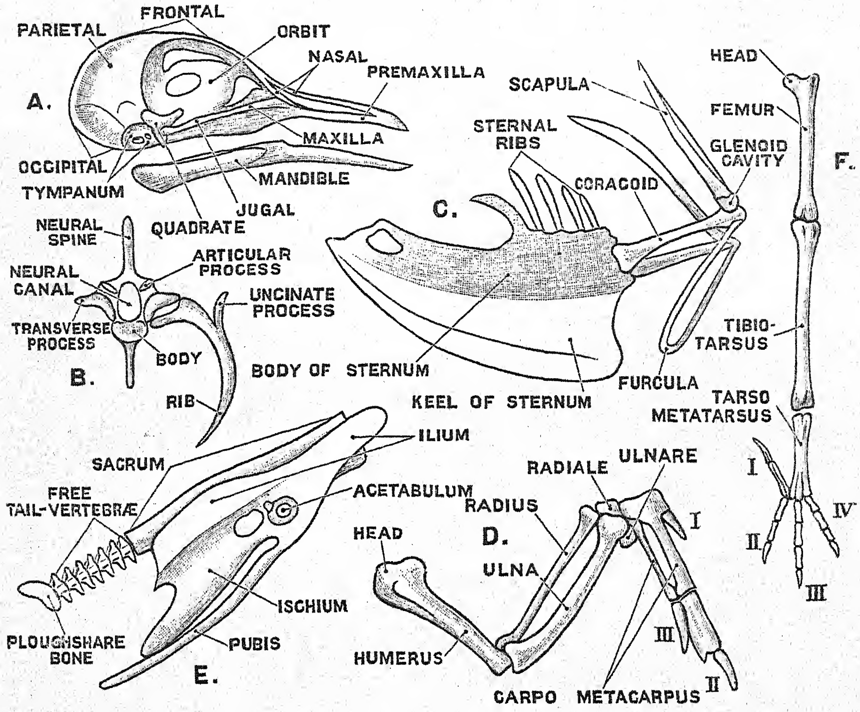


Fig. 101.—Skeleton of Pigeon

A, Skull; B, vertebra and rib (front view); C, sternum and shoulder-girdles; D, wing; E, pelvis and tail; F, leg.

together so as to confer great rigidity, an important matter in connection with the requirements of flight. What is called the "sacrum" in a pigeon is made up by the union of vertebræ belonging to very different regions, including one thoracic, six lumbar, two sacral proper, and five caudal. The remaining vertebræ of the abbreviated tail are ten in number, and the last four of them are fused into a laterally-flattened *ploughshare bone*, which supports the tail-quills.

Since the walls of the thorax are fairly mobile in a bird, and by their movement help in breathing, the breastbone and ribs are hinged on to the backbone so as to permit of this.

All the five thoracic vertebræ bear *ribs* which unite with the breastbone, and each rib in its upper section possesses a backward projection, the *uncinate process*, absent in all mammals. It should also be noted that the posterior neck vertebræ bear small free ribs.

The *breastbone* or sternum of a pigeon is exceedingly large, and is in particular distinguished by the presence of a very prominent vertical plate or keel on its under side. The use of this is to give a large surface to which the powerful muscles of flight are attached. A bat's sternum possesses a small keel for a similar reason.

Skeleton of Fore-Limb.—The special function of this being to serve as a firm support for the wing-quills, it is not surprising to find that the bones of the hand have undergone a good deal of reduction in number, and also of fusion, the digits being only three, corresponding to the thumb and first two fingers of a mammal. Such a hand skeleton as that described for Man (p. 31), made up of numerous small bones flexibly united together, is very suitable for a limb capable of performing all sorts of complicated movements, but much too elaborate for a mere support, as in the case of a wing.

The upper part of the limb skeleton, or *shoulder-girdle*, includes three bones: the dorsal narrow *scapula*, the rod-shaped ventral *coracoid* which unites with the sternum, and a collar-bone or *clavicle*. In the possession of a distinct coracoid, Birds and Monotreme Mammals agree (p. 138). The two narrow curved clavicles are firmly fused together into the familiar "merry-thought" or *furcula*, which acts as a spring and keeps the two wings well separated.

Skeleton of Hind-Limb.—The *hip-girdle* is made up of the same three elements as in a mammal, *i.e. ilium*, *ischium*, and *pubis*. The ilium is very large and runs both fore and aft, uniting by its inner surface with the long "sacrum", thus affording a very firm support to the body when the bird rests or walks. Both ischium and pubis, especially the latter, are narrow and backwardly-directed, and do not unite with one another in the mid-ventral line as in a mammal (see p. 31).

The chief peculiarity in the bones of the free part of the leg is found in the ankle, for the *tarsus*, instead of being made up of a number of small irregular bones, as in

the mammal (see p. 32), consists, in the very young bird, of two elements only, of which one fuses with the tibia to form a tibio-tarsus, while the other fuses with three of the metatarsals, these also uniting with one another, the compound product being known as the "tarso-metatarsus". It will thus be seen that what corresponds to the ankle-joint of the human foot (p. 32) comes in the middle of the tarsus, and not between it and the bones of the lower leg. The great toe possesses a metatarsal which is distinct from the others, and this digit therefore has a greater power of movement. The remaining point deserving mention here is in regard to the number of phalanges in the various toes. It will be remembered that in Man (p. 31), and the same thing is true for mammals generally, the great toe has two and the remaining toes three phalanges each. A bird has similarly two phalanges in the great toe and three phalanges in the second toe, but the third toe possesses four, and the fourth five, thus giving the regular succession two, three, four, five, each digit possessing one more phalanx than its number in the series.

Digestive Organs (fig. 99).—The pigeon, like all existing birds, is entirely devoid of teeth, and its beak is only useful for picking up food, not being capable of breaking up the hard grain on which the animal largely feeds. A temporary receptacle for food is therefore necessary, and this is found in the large *crop* into which the gullet swells. A further peculiarity, common to all birds, is found in the nature of the stomach, which consists of two parts, chemical stomach (proventriculus) and gizzard. The former looks like a swelling at the end of the gullet, but is distinguished by the presence of numerous *gastric* or *peptic glands* (see p. 37) imbedded in its mucous membrane, and secreting gastric juice. The *gizzard* is a rounded and somewhat flattened structure with a tough lining and exceedingly thick muscular walls. As is well known, it serves to grind up the food, its action being assisted by small stones and other hard bodies which are swallowed for the purpose. The stomach is followed by a long *small intestine* into which the *liver* and *pancreas* pour their secretions; and a much shorter *large intestine*, opening into a *cloaca*, which communicates with the exterior by a cloacal aperture.

Circulatory Organs (fig. 102).—As in a mammal, both blood

and lymph systems are present, but we need only consider a few points concerning the former.

The blood is much hotter than that of a mammal, maintaining a temperature of about 103° F. on the average as against 98° F., a fact which has relation to the extreme activity of birds, and the intensity, so to speak, of all their life processes. The well-developed investment of feathers by which the body is covered, and which entangles a large amount of air, is of great importance as a non-conducting coat, which prevents the too rapid dissipation of the heat of the body without checking ventilation of the body surface. A drop of pigeon's blood examined under the microscope shows the same constituents as are seen in a mammal (see p. 39), *i.e.* a liquid *plasma* in which are suspended *white* and *red corpuscles.* The latter, however, though discs, are of a pointed oval shape instead of being circular, and each of them encloses a firmer particle or nucleus.

The pigeon's *heart* and *blood-vessels* agree in essential respects with those of a mammal (see p. 39), but there are numerous differences in detail. Thus, though the heart is four-chambered and the impure blood of the right side is thus completely separated from the pure blood of the left side, there are differences as regards the valves, especially the one between right auricle and ventricle, which is a muscular flap instead of consisting of three membranous pieces. The great artery of the body, the *aorta*, where it arises from the heart, curves round to the right and not to the left. The enormously large muscles of flight, which make up the flesh of the breast, are provided with large blood-vessels.

Breathing Organs and *Organs of Voice* (fig. 102).—The separation between food-tract and breathing-tract is less complete here than in a mammal (see p. 34), for the hinder openings of the nasal cavities (*posterior nares*) are situated on the roof of the mouth instead of farther back. Upon the floor of the pharynx the slit-like glottis is situated, but this is not guarded in front by an epiglottis. It leads into the larynx, which is *not* in birds the organ of voice, and is continued into the very long windpipe (trachea) that divides into two branches (*bronchi*) for the lungs. These air-passages are not supported by hoops of cartilage, as in mammals (p. 46), but by bony rings. From this point onwards a number of striking peculiarities are

encountered, for the lungs do not constitute the only goal of the in-breathed air, but communicate with a number of thin-walled *air-sacs*, and these again with the air-filled cavities in the bones. The only other animals which are so thoroughly permeated by air are insects, and in them, as in birds, one end to be gained is the reduction of the specific gravity of the body as an aid to flight. The small *lungs*, though spongy, are not freely movable in the thoracic cavity, but are firmly fixed to its roof,

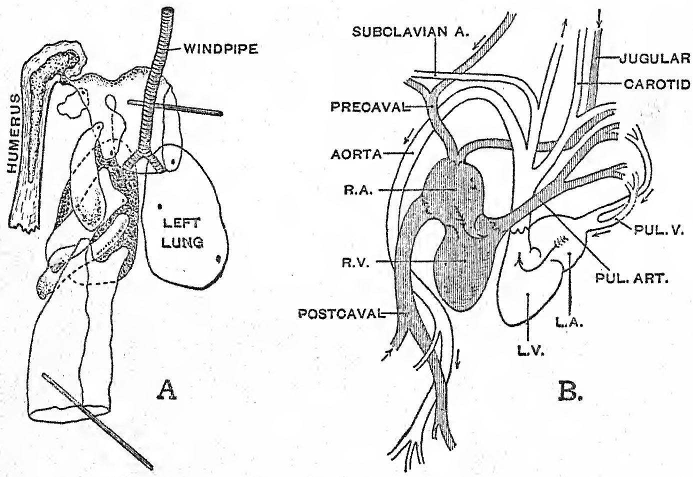


Fig. 102.—Structure of Pigeon

A, Respiratory organs, seen from vertical side. Air-sacs connected with right lung are drawn in outline. Rods are inserted into two cut air-sacs. B, Diagrams of heart and great blood-vessels, from ventral side. Two halves of heart shown as if separated, and direction of blood-flow indicated by arrows. R.A. and L.A., right and left auricles; R.V. and L.V., right and left ventricles; Pul. Art. and Pul. V., pulmonary artery and vein; A. and V. elsewhere mean artery and vein.

and there being no midriff as in a mammal (see p. 46), there is no sharp boundary between thoracic and abdominal regions. The bronchi branch out in their respective lungs, and their larger branches run to the lung surface, where they open into the large thin-walled air-sacs, which are placed in various positions. Some of the anterior air-sacs communicate with the air-spaces contained in certain bones, as, *e.g.*, the humerus and sternum. The mechanical part of breathing is brought about by the movement of the ribs and sternum, much as in a mammal (p. 46), but here there is, of course, no diaphragmatic breathing. The entering air rushes into all the air-sacs, and the work to be done by diffusion is not so great as in a mammal. The reason for this is, to keep the process of blood oxygenation

going very rapidly, as, if this were not the case, the high temperature of the body could not be maintained.

Voice.—Although the pigeon possesses a larynx, this is not the organ of voice, which consists of a structure known as the *song-box* or *syrinx*, formed by the modification of the extreme end of the windpipe and the beginning of the two bronchi to form a small resonant chamber (*tympanum*) into which an elastic fold projects. The sound is produced by vibration of this fold, and it can be stretched to various extents so as to alter the pitch of the note.

Organs of Movement.—As in the human subject, the *white corpuscles* of blood and lymph are able to creep about by means of amœboid movement (p. 39), and the windpipe and certain other structures are lined by *ciliated membranes* (p. 49); but, as before, the chief movements of the body are brought about by *muscular action.* The most interesting peculiarities in the muscular system are connected with flight and with perching. The large fleshy mass covering the breast is made up of the pectoral muscles, which are attached to the wings in such a manner as to pull them alternately up and down; but this is not the place to furnish details, which will be given farther on in connection with locomotion.

The *perching mechanism* is an arrangement by which the toes can be all brought together at the same time by a pull exerted upon a single tendon connected with two muscles of the leg. When a bird is roosting, the weight of the body bends the limb in such a way as to pull on this tendon and bring all the toes firmly against the branch or other supporting object, the danger of falling off during sleep being thus averted.

Nervous System (fig. 103).—The *brain* of the pigeon is extremely short and broad, and is distinguished by several peculiarities. The cerebral hemispheres are large and rounded, but are quite smooth externally, and are not, as in mammals, united across the middle line by a fibrous band or corpus callosum (see p. 52). Both these points are related to the comparatively small intelligence of the animal. The organs of smell are not well developed, and therefore, as might be expected, the olfactory lobes are of small size; but on the other hand, in accordance with the unusually acute vision, the optic nerves, optic tracts, and optic lobes are very large.

These last are two rounded elevations situated one on each side, while the corresponding parts in a mammal are four in number, and have a dorsal situation. The cerebellum is very large, and marked by deep transverse furrows.

Sense Organs (fig. 103).—Only the ear and eye deserve special mention under this heading. The *organs of hearing* consist, as in a mammal (see p. 56), of internal, middle, and external ears, but there are a number of differences in detail. The internal ear or membranous labyrinth differs most as regards the *cochlea*, which is a slightly-curved tube (lagena) instead of being spirally coiled. In the middle ear it may be noted that instead of a chain of auditory ossicles there is a minute rod, the *columella*, which runs across the tympanic cavity from its external membrane to the *fenestra ovalis*. The external ear consists simply of a passage leading down from the outside of the head to the tympanic membrane, there being no external flap or pinna.

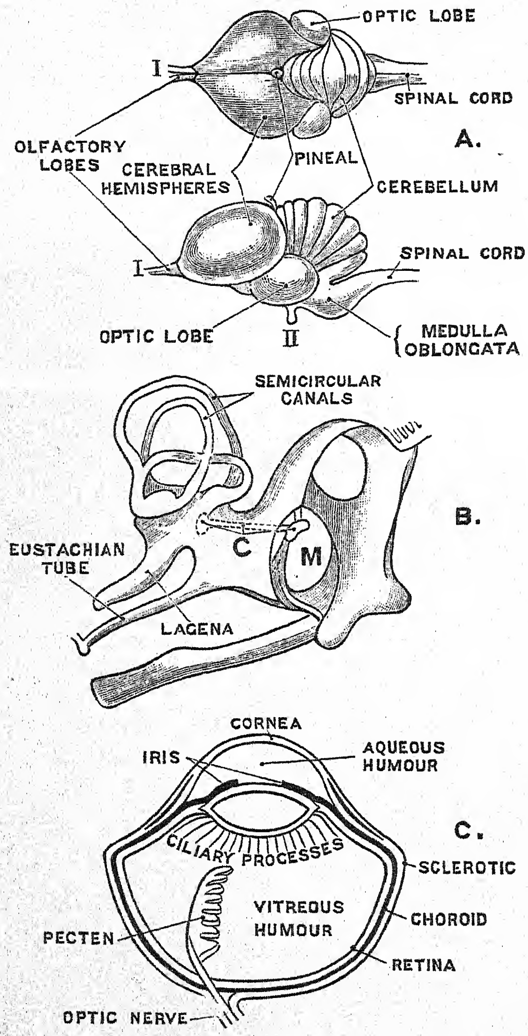


Fig. 103.—Structure of Pigeon

A, Brain from above and from left side: I, olfactory nerve; II, optic nerve. B, Organs of hearing (much enlarged); C, columella: M, position of tympanic membrane; C, Diagrammatic section of eye (enlarged).

It will be remembered, however, that the pinna is also absent in certain aquatic mammals, such as the whales and the true seal.

The *eye* of a bird is not, as in a mammal, approximately spherical, but consists of outer and inner halves possessing very

different degrees of curvature, the former almost resembling a cone with its apex rounded off instead of being pointed. Within the outer part of the sclerotic, or firm white external eye-coating, there is a circlet of small overlapping bony plates. The remaining most striking difference is seen in the presence of a *pecten*, a folded structure which projects into the vitreous humour close to the point where the optic nerve pierces the eyeball to branch up in the retina or sensitive innermost eye-coating.

It was noticed under external characters that there is a third eyelid in addition to the usual upper and lower ones. Some mammals, as the rabbit, possess such an eyelid, though it is not so mobile.

Development (fig. 104)—All birds lay eggs, protected externally by a firm limy *shell*, and the lowest mammals agree with them

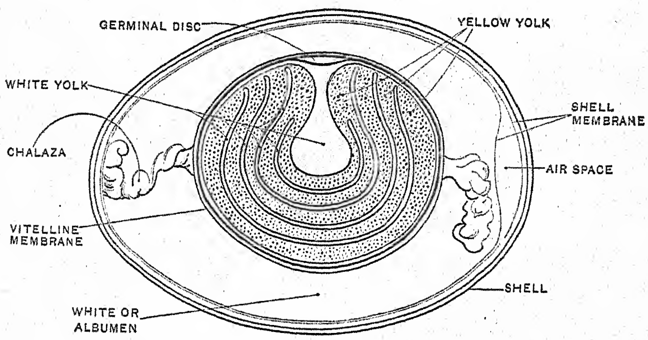


Fig. 104.—Structure of Hen's Egg

in this respect. One or both parents in turn sit upon or incubate the eggs, thus providing the necessary warmth without which the young bird cannot develop. Most of the egg consists of material which will serve for the nourishment of the embryo, the body of which is evolved from a very small patch (*germinal disc*), to be seen on one side of the yellow part known as the *yolk*. The part of the yolk on which the germinal disc rests is lighter than the rest, and this side therefore floats upwards in the glairy matter termed the "white", or more properly speaking the *albumen*. Hence the embryonic part of the egg is kept constantly turned towards the source of heat, *i.e.* the incubating parent. Young pigeons are hatched in a very imperfect state, and have to be fed for some time by the parents, part of their food consisting of a whitish material, the so-called "pigeon's milk", secreted by the

lining of the crop. The helpless nestling is very imperfectly clad with feathers, and these down-feathers are much simpler in nature than the ordinary feathers of the adult bird.

CLASSIFICATION OF BIRDS

Excluding fossil forms, birds are divided into two sub-classes of very unequal size: I. Flying Birds (Carinatæ), of which the Pigeon is an example; and II. Running Birds (Ratitæ), of which the best-known kind is the Ostrich.

I. FLYING BIRDS (Carinatæ) are more or less perfectly adapted for flight, as will have been seen from the typical example just described. The most striking characters are found in the structure of the wings and the keeled sternum, in reference to which latter feature the group is technically called Carinatæ (L. *carina*, a keel).

Although the existing species of flying birds are extremely numerous, they agree so closely among one another in most essential features that it is exceedingly difficult to divide them into orders, but eighteen of these are commonly recognized, though the distinctive characters of many of them are founded upon comparatively trivial matters, and we do not get the broad lines of division existing in the case of Mammals. The orders are as follows:—

1. Perching Birds (Passeres); 2. Picarian Birds (Picariæ); 3. Owls (Striges); 4. Parrots (Psittaci); 5. Pigeons and Sand-Grouse (Columbæ); 6. Gulls (Gaviæ); 7. Plovers (Limicolæ); 8. Bustards and Cranes (Alectorides); 9. Rails (Grallæ); 10. Game-Birds (Gallinæ); 11. Tinamous (Crypturi); 12. Eagles and Vultures (Accipitres); 13. Ducks, Geese, and Flamingoes (Anseres); 14. Herons and Storks (Herodiones); 15. Pelicans and Cormorants (Steganopodes); 16. Petrels and Albatrosses (Tubinares); 17. Divers and Grebes (Pygopodes); 18. Penguins (Impennes).

Order 1.—PERCHING BIRDS (Passeres).

This order is regarded as the highest of the sub-divisions of birds, and the large majority of them are included in it, more particularly those which are familiarly known as "song-birds". The first toe can be moved independently of the others, which is not the case in other birds, and possesses a larger claw than

they do. In most cases the back of the metatarsus is protected by two narrow elongated plates, instead of by scales. There are generally ten, or it may be nine, primary quills in the wing, which is covered by only a few small contour feathers. The tail-quills are usually twelve in number. The young are helpless and almost destitute of feathers.

Among the enormous number of birds included in this order are the following representatives of important families:—1. Crows; 2. Birds of Paradise; 3. Bower-Birds; 4. Starlings; 5. Orioles;

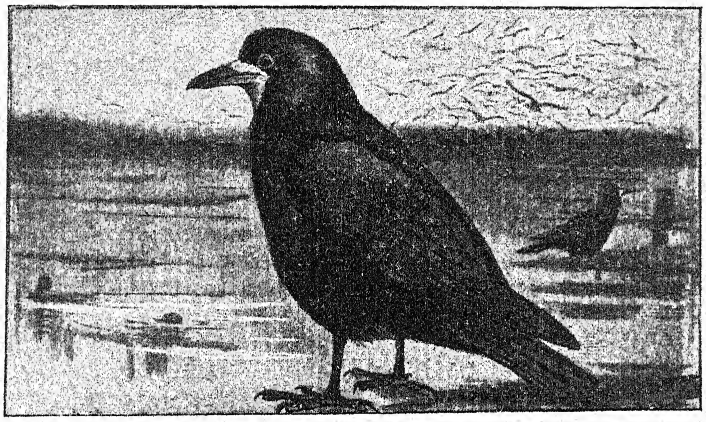


Fig. 105.—Rook (*Corvus frugilegus*)

6. Finches; 7. Weaver-Birds; 8. Buntings; 9. Larks; 10. Wagtails; 11. Creepers; 12. Nuthatches; 13. Sun-Birds; 14. Tits; 15. Shrikes; 16. Thrushes and Warblers; 17. Wrens; 18. Swallows; and 19. Lyre-Birds. The British species belonging to these families, if any, will be enumerated, except in the case of rare stragglers.

1. *Crows* and their allies are large birds with strong beaks, and nostrils protected by bristles. Many of them are black or black and white, and they are practically cosmopolitan, being absent, however, from New Zealand, Among British forms the Raven (*Corvus corax*) is entirely black, as are the Carrion Crow (*Corvus corone*) and the Rook (*Corvus frugilegus*) (fig. 105), there being, however, in the latter a bare patch extending round the base of the beak. The Jackdaw (*Corvus monedula*) has a grey neck, while the long-tailed Magpie (*Pica rustica*) is black and white, as the name indicates. The Jay (*Garrulus glandarius*) is a much more brightly-coloured member of the same family, its

plumage exhibiting white, black, brown, and blue, while there is a handsome crest upon the head.

The remaining British species are: Hooded Crow (*Corvus cornix*), Nutcracker (*Nucifraga caryocatactes*), Chough (*Pyrrhocorax graculus*).

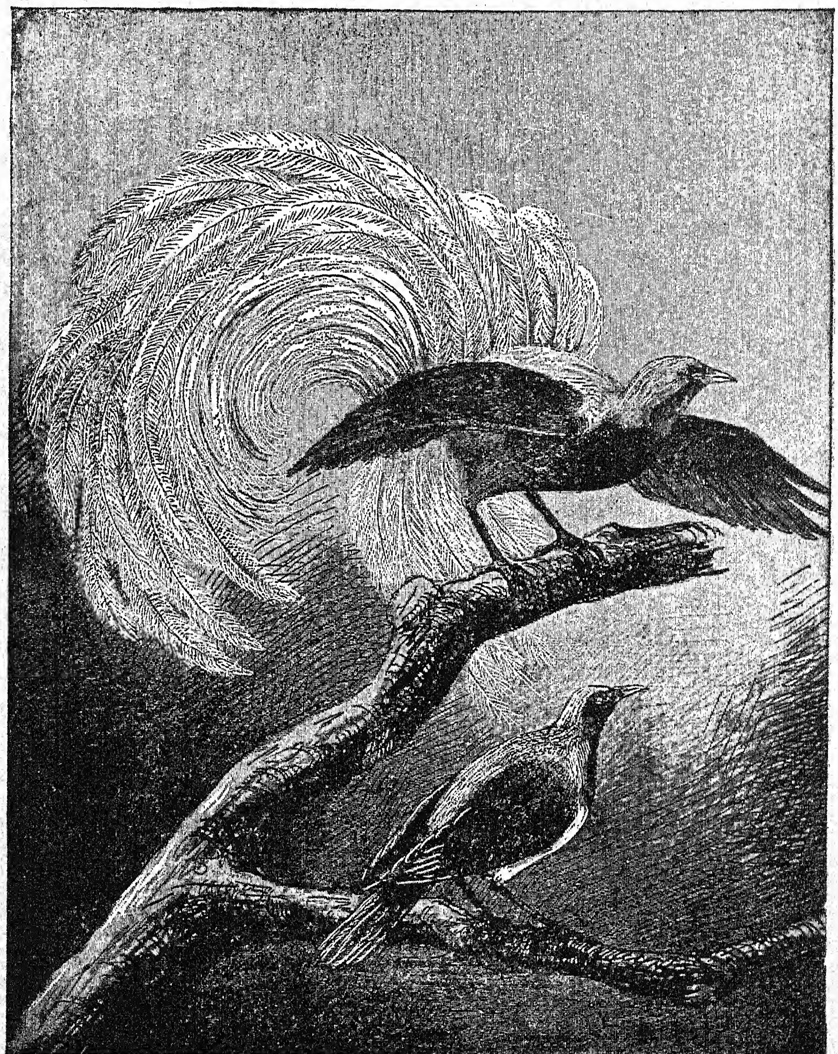


Fig. 106.—Great Paradise Bird (*Paradisea apoda*)

2. The *Birds of Paradise* are closely related to the crows in structure, but are remarkable for the gorgeous and varied plumage of the males, certain of the feathers being prolonged and modified in various ways. The region from which such feathers spring differs in different species. Birds of Paradise are for the most

part limited to New Guinea and the neighbouring islands, though they also range into the north of Australia. The Great Paradise Bird (*Paradisea apoda*) of the Aru Islands is depicted in fig. 106.

3. *Bower-Birds* constitute a small family mainly confined to Australia, though also found in New Guinea, and are chiefly interesting because they construct and decorate so-called "bowers", which appear to be solely used for the purpose of amusement. A well-known form is the Satin Bower-Bird of New South Wales (*Ptilonorhynchus holosericeus*).

Fig. 107.—Starlings
Common Starling (*Sturnus vulgaris*).

4. *Starlings* (fig. 107) constitute a well-known family with a wide distribution in the Eastern hemisphere, being absent only from Australia. They do not, however, occur in America. The beak is fairly long and often slightly curved, while its base is free from bristles. Flocks of these birds can often be seen in meadows hunting for insects and worms. Another characteristic feature is that of the ten primary wing-quills; the first is less than half the length of the second.

The Common Starling (*Sturnus vulgaris*), immortalized in Sterne's *Sentimental Journey*, is a refreshing exception to the general rule for British birds, its numbers being on the increase. The black plumage, shot with green and blue, and tipped with buff, is extremely handsome. There is one other British species, the Rose-coloured Starling (*Pastor roseus*).

5. *Orioles* or Golden Thrushes are characteristic of Africa and South Asia, though they are represented in Australia and Europe. The beak is slender and almost straight, the legs short, and the plumage brilliant.

The Golden Oriole (*Oriolus galbula*) of continental Europe

and South-west Asia is known as a visitor in this country. In colour it is golden-yellow, with black on the wings and tail, and the call-notes of the male are flute-like in tone.

6. *Finches* make up a very large family, absent only from the Australian region, and characterized by strong conical beaks adapted for feeding upon seeds and grain, while there are only nine primary wing-quills instead of ten. The food is by no means limited to seeds and the like.

The following small British birds belong here:—Sparrow (*Passer domesticus*); Tree-Sparrow (*P. montanus*); Bullfinch (*Pyrrhula Europæa*); Chaffinch (*Fringilla cœlebs*); Brambling (*F. montifringillina*); Linnet (*F. cannabina*); Mealy Redpole (*Cannabina linaria*); Lesser Redpole (*C. rufescens*); Twite (*C. flavirostris*); Greenfinch (*Ligurinus chloris*); Goldfinch (*Carduelis elegans*); Hawfinch (*Coccothraustes vulgaris*); Siskin (*Chrysomitus spinus*); Crossbill (*Loxia curvirostra*).

7. *Weaver-Birds*, remarkable for the way in which they intertwine fibres to form their nests, resemble finches in appearance and in their stout conical beaks, but possess ten instead of nine primary wing-quills as in the latter. The family is more particularly characteristic of Africa south of the Sahara, but is also well represented in South Asia and in Australia. The Java Sparrow or Rice-Bird (*Munia oryzivora*) is familiar in this country as a cage-bird.

8. *Buntings* are finch-like forms inhabiting the colder parts of the Old World. They differ from the true finches in minor features, one of which is that when the beak is shut its edges do not come into contact except at the base and tip.

There are several British species, of which the most familiar is the Yellow Bunting (*Emberiza citrinella*), better known as the Yellow Hammer.

The remaining British species are:—Cirl Bunting (*Emberiza cirlus*); Corn Bunting (*E. miliaria*); Reed Bunting (*E. schœniclus*); Snow Bunting (*Plectrophenax nivalis*).

9. *Larks* constitute a tolerably large group, limited with but few exceptions to Europe, Asia, and Africa, where they are most abundant in plains and deserts. Their powers of song are known to everyone. The first toe is provided with a very long straight claw.

The Skylark (*Alauda arvensis*) and Woodlark (*A. arborea*) are well known in Britain. The Shore Lark (*Otocorys alpestris*) is a visitor.

10. *Wagtails*, with their allies the *Pipits*, make up a small family which, though found in all parts of the world, except the Pacific Islands, is especially characteristic of the northern parts of Europe and Asia. The body is slender and the tail long. The narrow-pointed beak is well suited for the capture of insects, and the feet are somewhat like those of larks, except that the claw of the first toe is more curved. Most of the birds here included are found chiefly on the ground, and run very quickly.

Common British species are the following:—Pied Wagtail (*Motacilla lugubris*); Meadow Pipit or Titlark (*Anthus pratensis*).

The other native species are the following:—White Wagtail (*Motacilla alba*); Blue-headed Wagtail (*M. flava*); Grey Wagtail (*M. melanope*); Yellow Wagtail (*M. Raii*); Rock Pipit (*Anthus obscurus*); Richard's Pipit (*A. Richardi*); Tree Pipit (*A. trivialis*).

11. *Creepers* are a small family of wide distribution, with long curved beak and sharp claws. They are adapted for the pursuit of insects upon the trunks of trees, walls, and similar places.

The only resident British species is the Tree Creeper (*Certhia familiaris*), which has a wide range in the Northern hemisphere. Though fairly common, its plumage harmonizes so well with the surroundings that it often escapes observation. The tail is stiffened, and its pointed quills are of great assistance in climbing.

12. *Nuthatches* constitute another small family of climbing birds, somewhat more widely distributed than the Creepers, being absent only from South America, Africa south of the Sahara, and the Pacific Islands. They differ in no very important respect from the Creepers. Their food consists not merely of insects, but also of nuts.

Our only native species is the Nuthatch (*Sitta cæsia*), common in the wooded parts of Central and South Europe, and also found in North Africa. It also ranges into South-west Asia, but, unlike the Creeper, is unknown in North America.

13. The *Sun-Birds* are small, brilliantly-coloured forms ranging through the tropics of the Old World, and often confounded with the humming-birds, which they resemble in appearance and habits, though there is no close relationship between the two groups.

14. *Tits* or *Titmice* are small active birds, the general appearance of which is well known to everyone, and which, though

specially characteristic of the northern hemisphere, are found in most parts of the world. The beak is short and conical, and the first wing-quill is never more than half the length of the second one. These birds inhabit trees, and chiefly feed on insects, though vegetable food is by no means disdained. A meat-bone or partly-opened cocoa-nut placed outside the window of a house is almost certain to attract any tits which may be in the neighbourhood.

The best-known British species is the Blue Titmouse (*Parus cœruleus*), which possesses extremely beautiful plumage, exhibiting shades of blue, yellow, yellowish-green, and white. It ranges throughout most of Europe, and is abundant in Asia Minor.

Other typical native forms are:—Coal-Tit (*Parus ater*); Crested Tit (*P. cristatus*); Great Tit (*P. major*); Marsh Tit (*P. palustris*); Long-tailed Tit (*Acredula caudata*).

15. *Shrikes* make up a fairly large family of tree-inhabiting birds which have their head-quarters in Africa, though they are found in all parts of the world, except South America and New Zealand. Their food consists of insects, and also in some cases of small vertebrates, and in accordance with this the beak is strong and often somewhat hooked.

The most abundant British species is the Red-backed Shrike (*Lanius collurio*), the plumage of which is mainly chestnut above and buff on the under side. Like other "butcher-birds", as these forms are often called, this form has the habit of impaling its victims upon sharp thorns. Its range includes most of Europe, South-west and Central Asia, and in winter it is found as far south as the Cape. Another native form is the great Grey Shrike (*L. excubitor*).

16. *Thrushes* and *Warblers* together constitute an enormous group of cosmopolitan birds distinguished for their powers of song. The beak is slender and bent a little at the end, and the first wing-quill is very short. Some feed entirely on insects, but others eat berries and the like as well. The plumage is quiet in colour, and there is not much difference in this respect between the sexes.

Thrushes are stoutly-built omnivorous birds, in which the young differ from the adults in their spotted plumage. They are commonest in South America, but are found in all parts of the world, except Madagascar and New Zealand.

Fig. 108.—Warblers

1. Barred Warbler (*Sylvia nisoria*). 2. Lesser Whitethroat (*S. curruca*). 3. Garden Warbler (*S. hortensis*). 4. Whitethroat (*S. cinerea*). 5. Blackcap (*S. atricapilla*).

Common British forms are the Song-Thrush (*Turdus musicus*), Fieldfare (*T. pilaris*), and Blackbird (*T. merula*), all of which are widely distributed in Europe, Asia, and North Africa.

The remaining native thrushes and thrush-like birds are:—Redwing (*Turdus iliacus*); Ring-Ousel (*T. torquata*); Missel-Thrush (*T. viscivorus*); Red-spotted Bluethroat (*Cyanecula suecica*); Nightingale (*Daulias luscinia*); Robin Redbreast (*Erithacus rubecula*); Whinchat (*Pratincola rubetra*); Stonechat (*P. rubicola*); Wheatear (*Saxicola œnanthe*); Redstart (*Ruticilla phœnicurus*); Black Redstart (*R. tithys*).

Warblers (fig. 108) are smaller and slenderer birds than thrushes, and more insectivorous in their habits. There is not the same difference of plumage between young and adult birds as in thrushes. Though the group is cosmopolitan, it is essentially characteristic of the Old World.

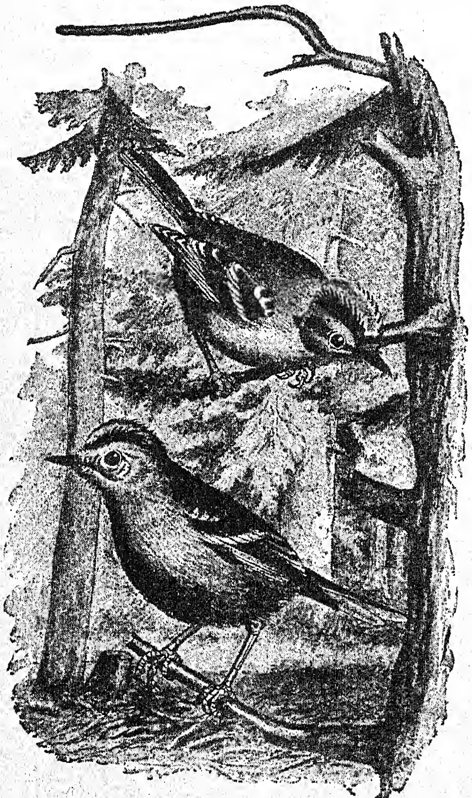


Fig. 109.—Golden-crested Wren (*Regulus cristatus*) below; Fire-crested Wren (*R. ignicapillus*) above.

Among the numerous British species may be mentioned:—Whitethroat (*Sylvia cinerea*); Golden-crested Wren (*Regulus cristatus*, the smallest of European birds) (fig. 109); Sedge Warbler (*Acrocephalus phragmitis*); and Hedge-Sparrow (*Accentor modularis*).

Our remaining species of warblers are:—Lesser Whitethroat (*Sylvia curruca*); Blackcap Warbler (*S. atricapilla*); Garden Warbler (*S. hortensis*); Dartford Warbler (*S. undata*); Marsh Warbler (*Acrocephalus palustris*); Reed Warbler (*A. streperus*); Grasshopper Warbler (*Locustella nævia*); Chiffchaff (*Phylloscopus rufus*); Wood-Wren (*P. sibilatrix*); Willow-Wren (*P. trochilus*); Fire-crested Wren (*Regulus ignicapillis*) (fig. 109).

17. *Wrens*, properly so called, are small birds with fairly long, straight, or nearly straight, beaks and rounded wings. The tail is usually carried bent up over the back. Commonest in South America, these birds are also found in North America, Europe and some parts of Asia.

The Common Wren (*Troglodytes parvulus*) of Britain is

essentially an European bird, but is also found in South-west Asia and parts of North Africa.

18. *Swallows* are cosmopolitan birds with remarkable powers of flight. The beak is short and broad at the base, the feet weak, the wings very long and pointed, and the tail generally forked. The food consists of insects, which, as is well known, are caught on the wing.

The three British species are the Swallow (*Hirundo rustica*), the House-Martin (*Chelidon urbica*), and the Sand-Martin (*Cotile riparia*). All three have a wide distribution in Europe, Asia, and Africa, while the Sand-Martin also ranges from the north of North America as far south as the Amazon valley.

19. *Lyre-Birds*, remarkable for the shape assumed by the tail of the male, have no very near allies. They are only found in South and East Australia.

Order 2.—Picarian Birds (*Picariæ*)

This large order resembles that of the perching birds in many respects, but is distinguished by slight anatomical differences of too technical a nature to be given here. Most members of the group lay white eggs in holes or other places likely to escape observation.

Among other families, those of 1. Woodpeckers, 2. Toucans, 3. Cuckoos, 4. Humming-Birds, 5. Swifts, 6. Night-Jars, 7. Hoopoes, 8. Hornbills, and 9. Kingfishers, may be more especially noticed.

1. *Woodpeckers.*—These are tree-climbing birds, in which the fourth toe is turned back parallel to the first (zygodactyle type of foot), while the strong chisel-shaped beak is used both in the pursuit of insects and to dig out holes for nesting purposes. The long worm-like tongue, which, covered by a sticky secretion, is used to capture insects, can be protruded to a considerable distance, and the related muscles and bones are specially modified, as will be described elsewhere. The young are helpless. Woodpeckers range over the entire globe, with the exception of Australasia.

There are three British species, of which the best known is the Green Woodpecker (*Gecinus viridis*), a form which is distributed over most of Europe, and also ranges into Asia Minor

and Persia. The other two are the Great Spotted Woodpecker (*Dendrocopus major*) and the Lesser Spotted Woodpecker (*D. minor*).

2. *Toucans* are South American birds, distinguished by exceedingly gay plumage and an enormous flattened bill, which also is brightly coloured. Their feet are zygodactyle.

3. *Cuckoos* are long-tailed birds, with feet like those of woodpeckers, the fourth and first toes being turned backwards.

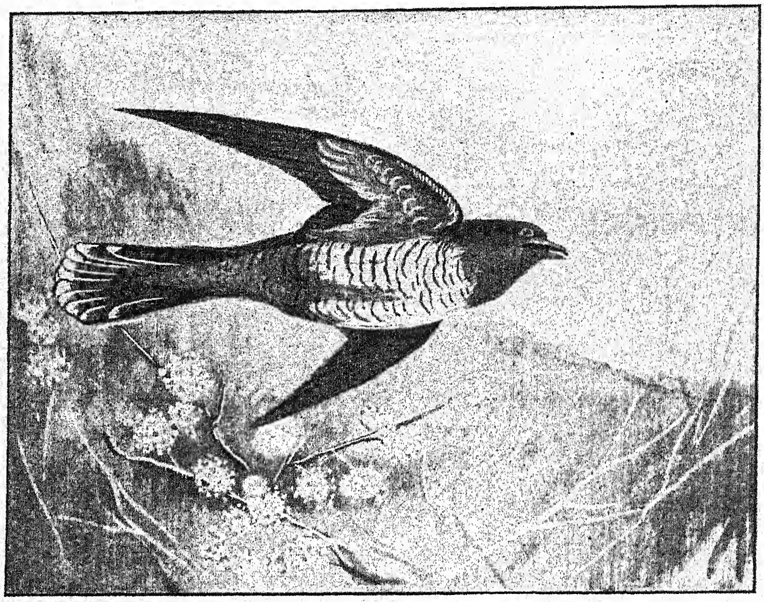


Fig. 110.—Cuckoo (*Cuculus canorus*)

They range over most of the globe, but their head-quarters are in tropical regions. Most of the Old World species lay their eggs in the nests of other birds, but the New World species build nests of their own.

The Common Cuckoo (*Cuculus canorus*) (fig. 110), which is a British resident from April to August (though the young birds may stay later), somewhat resembles a hawk in appearance, and is often taken for such not only by human beings but also by small birds. The familiar cry is uttered by the male only, the note of the female being quite different. It may be interesting to remark that the "cuckoo" call is only possessed by this species and by a South African form (*Cuculus gularis*). The common cuckoo ranges over most of Europe, Africa, and Asia.

4. *Humming-Birds*, remarkable for their small size, remarkable powers of flight, and, as a rule, the metallic brilliancy of their plumage, range from Mexico to the extreme south of South America. The beak in the adult is long and slender, and the tongue has an elaborate mechanism for pushing it out and pulling it back, much as in woodpeckers. Only the first toe is turned backwards.

5. *Swifts* are swallow-like birds with very long pointed wings, conferring considerable powers of flight. The short beak is broad at its base, and the mouth is consequently wide. A swift can easily be distinguished from a swallow by counting the tail-quills, which are ten in number instead of twelve. The distribution is world-wide, if New Zealand be excepted.

The Common Swift (*Cypselus apus*) of the British Isles is a summer visitor which nests in holes in roofs, walls, &c. With the exception of a light patch under the chin, it is of a blackish colour, the tail is forked, and the exceedingly small feet have all four toes directed forwards. This species ranges over the greater part of the Old World.

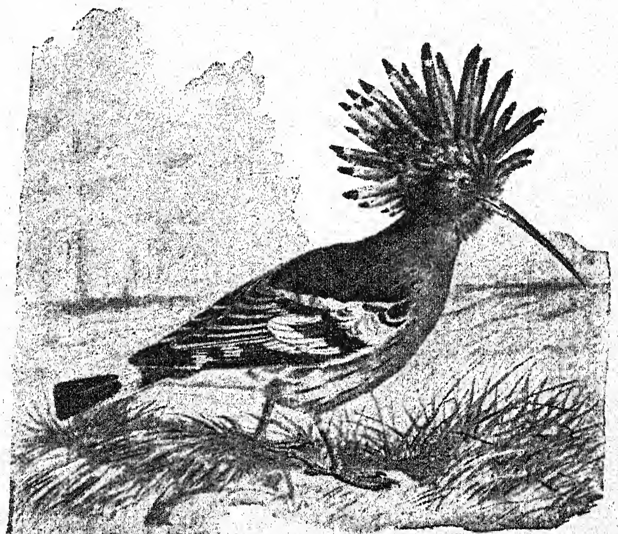


Fig. 111.—Hoopoe (*Upupa epops*)

6. *Night-Jars* or *Goat-Suckers* are mottled forms with broad beaks like those of swifts, and hair-like feathers in the neighbourhood of the mouth. The spotted eggs are laid in open places, and the young are thickly covered with down. Members of the group are found in all parts of the world, except New Zealand and some of the islands of the Pacific.

The European Night-Jar (*Caprimulgus Europæus*) is found in these islands from mid-May till September, or it may be later. Its range includes most of Europe and Africa and South-west Asia.

7. *Hoopoes* in many respects resemble the perching birds,

with which they are often included. The well-developed first toe is turned backwards. They are essentially desert forms, and their beautiful plumage is coloured so as to largely harmonize with surroundings of the kind. The head is distinguished by its long slender curved beak and handsome crest of features, which can be raised or depressed at will.

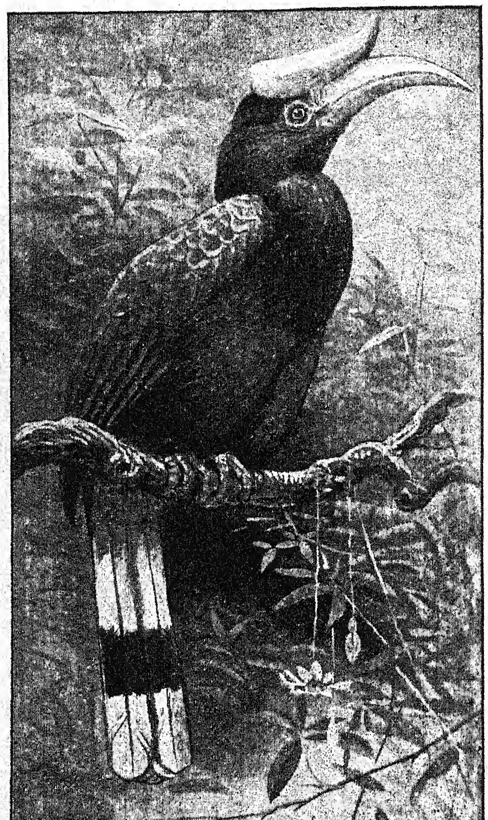


Fig. 112.—Rhinocéros Hornbill (*Buceros rhinoceros*)

The European Hoopoe (*Upupa epops*) (fig. 111) is a fairly common visitor to Britain.

8. *Hornbills* (fig. 112) are large tropical birds, ranging from Africa to the Solomon Islands, and distinguished by the possession of enormous beaks, which in some cases have a large projection or casque on the upper side at the base.

9. *Kingfishers* are distinguished by the structure of their feet, in which the great toe is backwardly directed, and the two outer toes united together. The beak is strong and pointed, varying in shape according to the food, which in one group consists of fish, in the other of reptiles and small mammals. Kingfishers have a world-wide distribution, but are most abundant in the Australian half of the East Indies, from Celebes to New Guinea, to which area the majority of the genera are confined.

The European Kingfisher (*Alcedo ispida*), which is a well-known British resident, is distinguished by its beautiful plumage, in which various shades of blue predominate above while the under surface is chestnut-coloured. As in the fish-eating species generally, the beak is long and pointed, while the tail is short. As an example of the reptile-eating kingfishers, the Laughing

Jackass (*Dacelo gigantea*) (fig. 113) of Australia and New Guinea may be taken. Here the beak is broader and stronger, and the tail is longer than in fish-eating forms.

Order 3.—Owls (*Striges*)

Here are included birds of prey, which are mostly nocturnal, and of characteristic appearance mainly due to the large forwardly-directed eyes surrounded by discs of radiating feathers. The four toes of the strong feet are all provided with sharp claws, and the fourth toe is reversible, being turned forwards or backwards at will. In flight these birds are peculiarly noiseless, their plumage being extremely soft. The young are helpless. Owls are universally distributed, and in all countries are regarded with awe by the superstitious, which is no doubt the result of their peculiar appearance and habits, aggravated by a most unearthly voice.

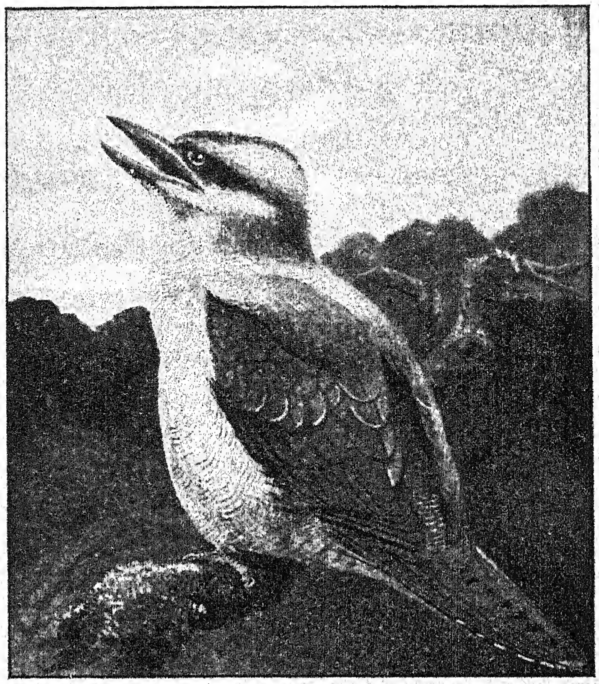


Fig. 113.—Laughing Jackass (*Dacelo gigantea*)

The most familiar British form is undoubtedly the Barn-Owl (*Strix flammea*), which is almost as universally distributed as the order to which it belongs. Other well-known native forms are the Tawny or Wood-Owl (*Syrnium aluco*), the "hoot" of which is a familiar country sound, the Long-eared Owl (*Asio otus*), and the Short-eared Owl (*Asio accipitrinus*). The "ears" of the last two kinds are tufts of feathers on the top of the head. The large Snowy Owl (*Nyctea Scandiaca*) regularly visits North Scotland during the winter.

The largest members of the group are the Great Horned or Eagle-Owls, of which the Great Eagle-Owl (*Bubo ignavus*) is sometimes caught in Great Britain, while the Pigmy-Owls are the smallest, being little more than half the size of the Barn-Owl. Interesting modifications of habit are found in the Hawk-Owl (*Surnia ulula*) of North Europe and Asia, which hunts its prey during the day; the Fish-Owls of Africa and South Asia, which frequent the neighbourhood of streams and lakes; and the little Burrowing-Owl (*Speotito cunicularia*) of America, which lives in the burrows excavated by rodents.

Order 4.—Parrots (*Psittaci*)

Parrots and the like constitute a large and well-marked group, the characters of which are familiar to almost everybody. The beak is short, stout, and hooked, a remarkable feature being that the upper jaw can be moved up and down as well as the lower jaw. A prominent cere is present. The legs are short and strong, while the feet are modified to serve as climbing organs, the fourth as well as the first toe being turned permanently backwards. The hooked beak is also used in climbing. The young birds are hatched in a helpless condition. The group is essentially tropical and sub-tropical, and is most abundantly represented, as regards number of species, in Australasia, from Celebes eastwards; while in abundance of individuals South America stands pre-eminent.

Probably the most familiar form is the common Grey Parrot (*Psittacus erithacus*) of Equatorial Africa. Its short square-ended red tail is distinctive. The *Cockatoos*, distinguished by their crests, are natives of Australia and the eastern Malay Islands, ranging also into the Philippines. The gorgeous long-tailed *Macaws* range from South America into Mexico, while the little *Love-Birds* are limited to Madagascar and Africa south of the Sahara. The *Parrotlets* are diminutive South American forms. Two small and peculiar families of parrots are confined to New Zealand and the neighbouring islands. One of these includes the Nestor-Parrots, of which the form known as the Kea (*Nestor notabilis*) has earned an evil reputation by its acquired habit of preying on sheep. The other family is constituted solely for the reception of the Kakapo or Owl-Parrot (*Stringops habroptilus*),

which has lost the power of flight and lives on the ground. The owl-like appearance is due to slender radiating feathers round the eye.

Order 5.—Pigeons and Sand-Grouse (Columbæ)

The description already given of a pigeon (p. 139) will give a good idea of the appearance and structure of the birds of this order.

Pigeons and *Doves* are distributed over the entire globe, but the largest number of peculiar genera and species are found in the southern land masses, especially Australia.

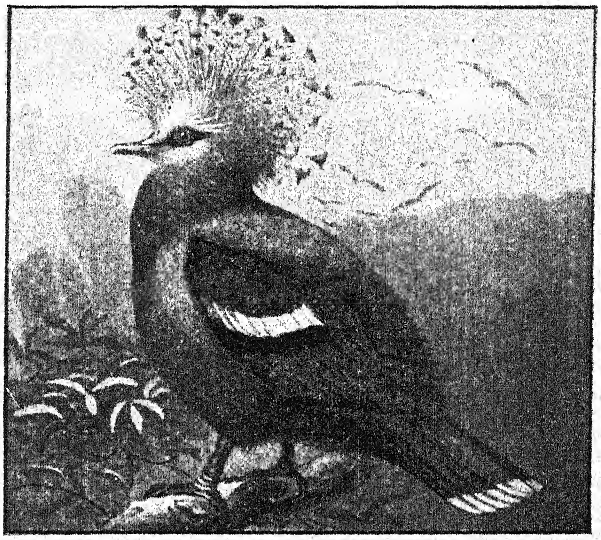


Fig. 114.—Crowned Pigeon (*Goura*)

British species are the Rock-Dove or Blue-Rock (*Columba livia*), the Ring-Dove, Wood-Pigeon, or Cushat (*C. palumbus*), the Stock-Dove (*C. œnas*), and, as a summer visitor, the Turtle-Dove (*Turtur communis*). Probably the most striking of exotic forms, and the largest members of the group, are the Crowned Pigeons of Australasia (fig. 114).

Sand-Grouse are essentially desert birds, and are quietly coloured to harmonize with their surroundings. Their head-quarters are Africa and Central Asia, also extending into South-west Europe and into India. Their unusually short legs and toes prevent them from perching, but the wings are long and pointed, conferring great powers of flight. The tail is also pointed. Some naturalists place these birds in a special order, and they have affinities with game-birds as well as pigeons, as shown by the structure of their digestive organs and the fact that their young are precocious.

Pallas's Sand-Grouse (*Syrrhaptes paradoxus*) inhabits, during summer, the steppes between the Caspian and Lake Baikal, migrating farther east in winter, and from time to time invades Europe in smaller or larger flocks, penetrating as far west as the British Isles.

Order 6.—Gulls (Gaviæ)

In many respects these birds resemble the plovers, and like them are cosmopolitan, and have precocious young. They differ, however, in being adapted to a marine life, as seen especially in the fact that the three front toes are connected by a web. It may also be noted that the plumage is entirely or largely light in colour.

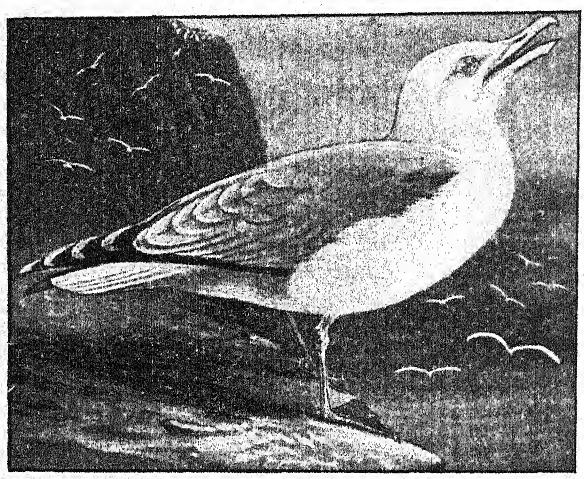


Fig. 115.—Herring-Gull (*Larus argentatus*).

Well-known British types are the Common Tern (*Sterna fluviatilis*), the Common Gull (*Larus canus*), the Herring-Gull (*Larus argentatus*) (fig. 115), and the Kittiwake (*Rissa tridactyla*).

The other British gulls, &c., are:—Lesser Black-backed Gull (*Larus fuscus*); Great Black-backed Gull (*L. marinus*); Glaucous Gull (*L. glaucus*); Iceland Gull (*L. leucopterus*); Little Gull (*L. minutus*); Black-headed Gull (*L. ridibundus*); Sandwich Tern (*Sterna Cantiaca*); Roseate Tern (*S. Dougalli*); Arctic Tern (*S. macrura*); Little Tern (*S. minuta*); Black Tern (*Hydrochelidon nigra*); Common Skua (*Stercorarius catarrhactes*) (fig. 117); Richardson's Skua (*S. crepidatus*); Long-tailed Skua (*S. parasiticus*); Pomatorhine Skua (*S. pomatorhinus*).

Order 7.—Plovers (Limicolæ)

Here are included birds with long pointed wings and long legs. The toes are not as a rule webbed, and the first toe is very small. Young precocious. The distribution is world-wide.

They include Plovers, Curlews, Phalaropes, Sandpipers (fig. 116), Woodcock, Snipe, &c.

British types are the Golden Plover (*Charadrius pluvialis*) (fig. 117), the Lapwing or Peewit (*Vanellus cristatus*), distinguished by its handsome crest and peculiar wailing cry, the

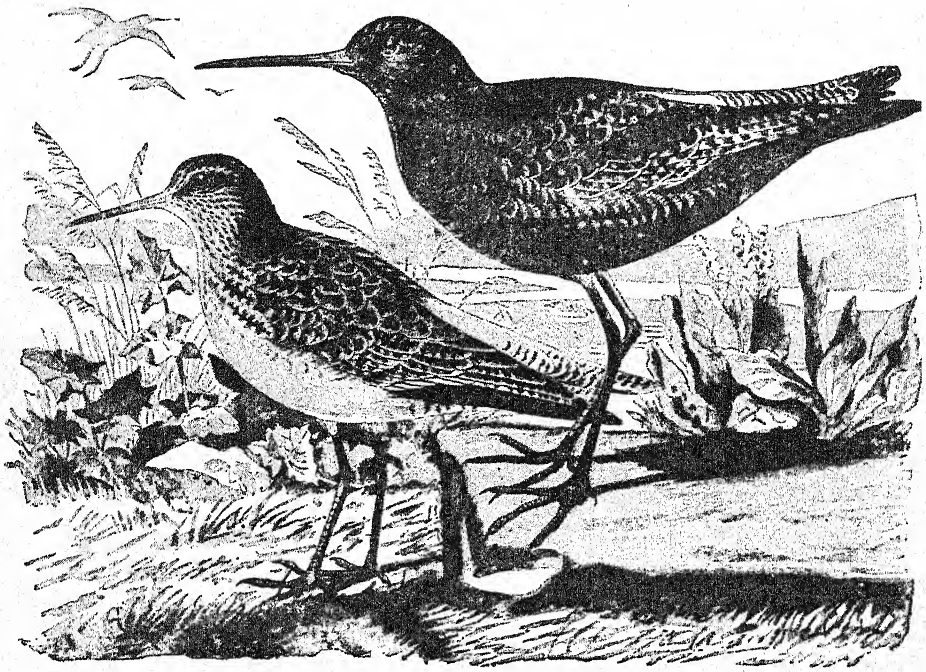


Fig. 116.—Sandpipers (*Totanus*)

Woodcock (*Scolopax rusticula*), and the Common Snipe (*Gallinago cœlestis*), both these last possessing long, straight, slender beaks.

The remaining British species are:—Stone Curlew (*Œdicnemus scolopax*); Pratincole (*Glareolus pratincola*); Ringed Plover (*Ægialitis hiaticula*); Kentish Plover (*Æ. Cantiana*); Dotterel (*Eudromias morinellus*); Oyster-Catcher (*Hæmatopus ostralegus*); Grey Plover (*Squatarola Helvetica*); Turnstone (*Strepsilus interpres*); Sanderling (*Calidris arenaria*); Bar-tailed Godwit (*Limosa Lapponica*); Black-tailed Godwit (*L. Belgica*); Great Snipe (*Gallinago major*); Jack Snipe (*G. gallinula*); Ruff (*Machetes pugnax*); Curlew (*Numenius arquata*); Whimbrel (*N. phæopus*); Grey Phalarope (*Phalaropus fulicarius*) (fig. 117); Red-necked Phalarope (*P. hyperboreus*); Common Sandpiper (*Totanus hypoleucus*); Wood Sandpiper (*T. glareolus*); Green Sandpiper (*T. ochropus*); Dunlin (*Tringa alpina*); Knot (*T. canutus*); Little Stint (*T. minuta*); Sharp-tailed Sandpiper (*T. acuminata*); Purple Sandpiper (*T. striata*); Curlew Sandpiper (*T. subarquata*); Temminck's Sandpiper (*T. Temmincki*).

Order 8.—Bustards and Cranes (Alectorides)

This is a somewhat artificial assemblage of forms which agree in many respects with the game-birds, differing, however, in minor anatomical characters. The young are precocious.

Bustards are thick-set birds common in the open parts of

Fig. 117.—Skuas (*Stercorarius*), Phalarope (*Phalaropus*), and Golden Plovers (*Charadrius*) (from left to right)

the Old World, including Australia. The Great Bustard (*Otis tarda*) was formerly abundant in Britain, but is now only an occasional visitor. The male possesses curious white "whiskers" made up of hair-like feathers.

Cranes resemble herons and storks in their general appearance, but are distinguished from them by a number of characters, one being that the short first toe is raised a little off the ground. Further, the young are precocious instead of being helpless. The Common Crane (*Grus cinerea*) (fig. 118) is now only seen wild in Britain as a rare visitor, but 300 years ago was common. It ranges over most of Europe, North Africa, and Asia.

Order 9.—Rails (Grallæ)

These cosmopolitan birds are closely allied to those of the following order, but are of more slender build, with feebler wings, shorter tail, and less compact plumage. Many of the species have lost the power of flight.

Common British examples are the Land-Rail or Corn-Crake (*Crex pratensis*), the peculiar creaking call of the male being a

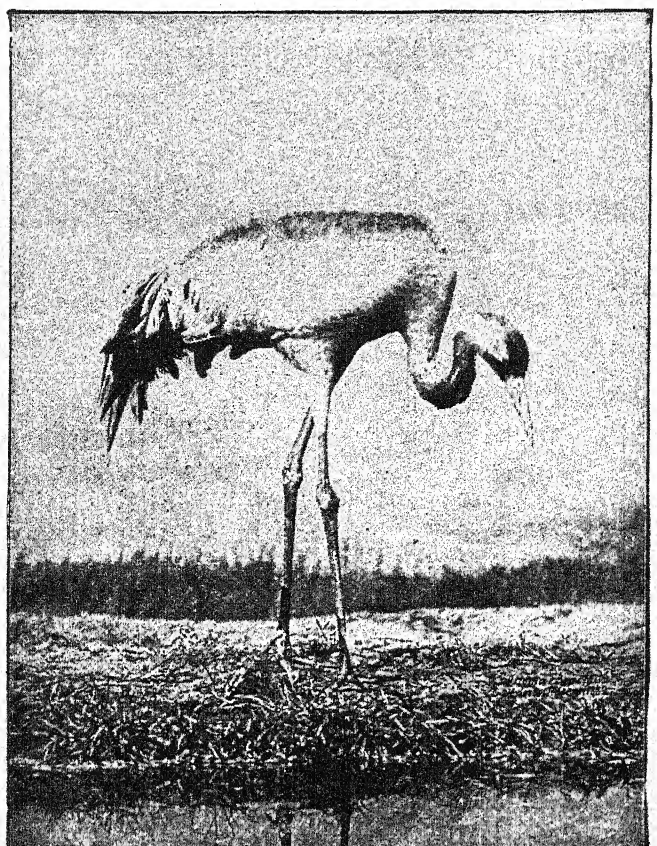


Fig. 118.—Common Crane (*Grus cinerea*). (From an instantaneous photograph)

familiar sound on summer evenings, the Water-Rail (*Rallus aquaticus*), the Moor-Hen (*Gallinula chloropus*), and the Coot (*Fulica atra*). The toes of the last-named species are lobed. The Spotted Crake (*Porgana marnetta*) also occurs in this country.

Order 10.—GAME-BIRDS (Gallinæ)

One has only to think of the appearance of ordinary fowls to realize the leading characteristics of this order. The body is plump and supported on strong legs adapted for rapid progression, and provided with strong claws suitable for scratching up the ground. The neck is fairly long, and the rounded head is provided with a strong beak, the upper half of which projects beyond the lower. The young are precocious, and soon able to look after themselves.

All the various domestic breeds of fowls, despite their extreme diversity in appearance, would appear to be descendants of the Red Jungle-Fowl (*Gallus Bankiva*), a species which ranges across North India from Kashmir to Assam, and also extends farther east as far as the Philippines. In general appearance these birds much resemble game-fowls, and, like their tame relatives, possess a notched fleshy comb, and a pair of wattles hanging from the throat.

Jungle-fowl are closely related to the *Pheasants*, which have a wide range in the Old World. The common Pheasant (*Phasianus Colchicus*) is not a native of this country, but of Asia Minor and South-east Europe. Other species extend the distribution of the group to East Asia, which must be considered its head-quarters. The male bird, as in so many other cases, is much more brightly coloured than the female, and this difference is emphasized in many exotic forms, as particularly in the Gold and Silver Pheasants (*Chrysolophus pictus* and *Gennæus nycthemerus*), both of which are natives of Eastern Europe.

Conspicuous among domesticated game-birds in this country are the Peacock (*Pavo cristatus*), found native in India and Ceylon, Guinea-Fowl (*Numida meleagris*), belonging, as the name indicates, to West Africa, and the Turkey (*Meleagris gallopavo*), from the southern parts of North America.

Other well-known inhabitants of Britain are: Partridge (*Perdix cinerea*); Red-legged or French Partridge (*Caccabis rufa*), introduced about a century ago; Quail (*Coturnix communis*); Capercailzie (*Tetrao urogallus*); Black Grouse (*Lyrurus tetrix*); Red Grouse (*Lagopus Scoticus*); and Ptarmigan (*L. mutus*), the last being remarkable for the changes of plumage exhibited at different seasons of the year.

The Red Grouse deserves special mention, for, with the exception of certain fresh-water fishes, it is the only vertebrate species peculiar to Britain.

Order 11.—Tinamous (Crypturi)

This is a small group of South American birds which are locally called "partridges", a name which at once suggests their general appearance and size. Though, however, appearing to have certain points in common with game-birds, they are also allied to flightless birds (ostriches, &c.), as is evidenced by the structure of the skull and by the much-reduced tail, the quills of which are not supported by a ploughshare-bone resulting from the fusion of the last few vertebræ (see p. 144).

Fig. 119.—Peregrine Falcon (*Falco peregrinus*)

Order 12.—Eagles and Vultures (Accipitres)

It has been a frequent practice to associate together as "birds of prey" eagles, vultures, owls, and their allies; but the association, like many others founded mainly on habit, is an artificial one, and it is now considered better to make two groups of such birds. The one under consideration includes those forms which hunt their prey in the daytime. The beak is hooked and the toes are furnished with formidable talons, but the great toe is not reversible as in owls, being permanently directed backwards. The plumage is compact, and the eyes face to the side.

Four groups are here included—Falcons, vultures, American vultures, and secretary-birds.

Falcons.—Most of these forms pursue living prey, while both head and neck are as well provided with feathers as the other parts of the body.

As a type of the true falcons, the Peregrine Falcon (*Falco peregrinus*) may be taken, and this form is of particular interest on account of its former use in hawking. The head and upper side of the body are dark, and the under side light with black barrings (fig. 119). The short beak is notched at the sides, and the legs and cere are yellow. It ranges through Europe and away to Japan in the east and North-east Africa in the south.

The Kestrel or Windhover (*Falco tinnunculus*) is a familiar species closely related to the preceding, but much smaller. Its range is similar.

The remaining British Falcons are:—Merlin (*Falco æsalon*); Hobby (*F. subbuteo*); Red-footed Falcon (*F. vespertinus*).

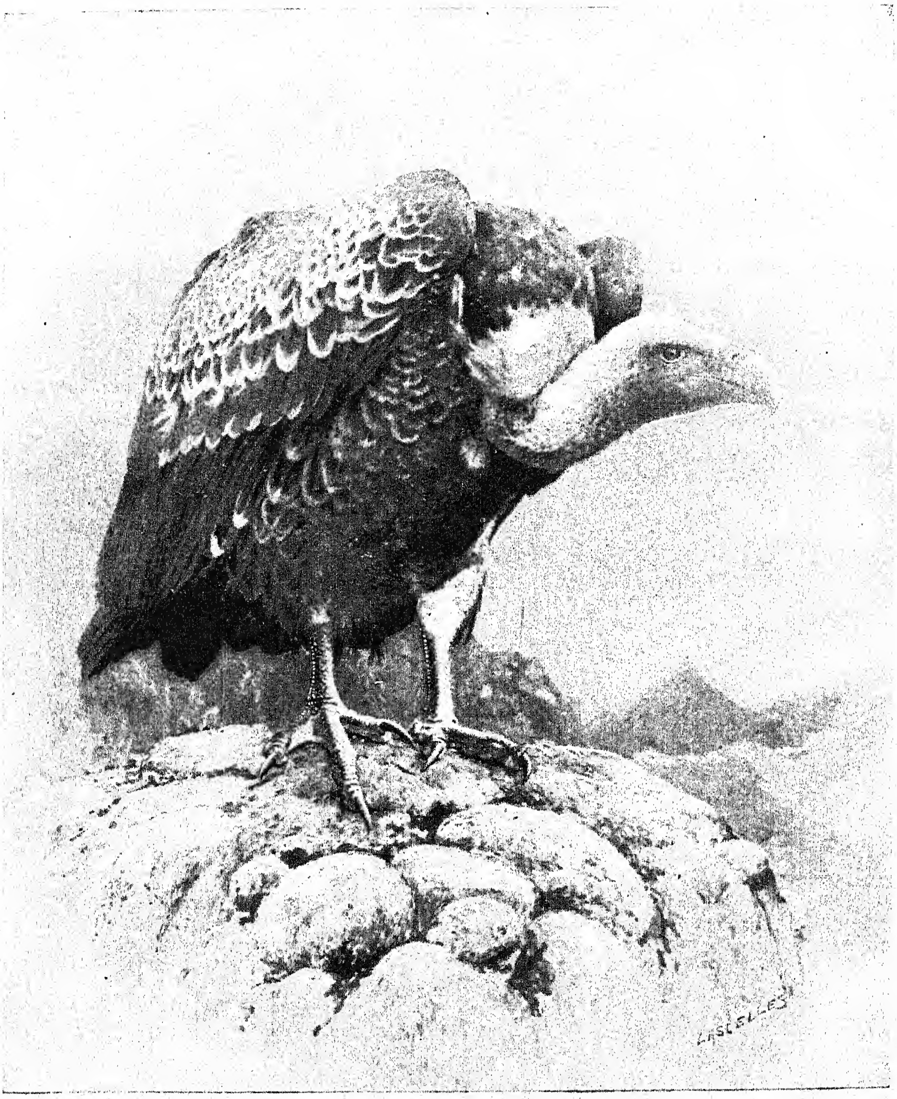
Another group closely related to the true falcons is that of eagle-like birds, including not only eagles, but also kites, buzzards, hawks, and harriers. The eagle par excellence is the Golden Eagle (*Aquila chrysaëtus*), of which the eyries are still to be found in the Highlands and along the west and north of Scotland, while a few are to be seen on the west coast of Ireland. Its geographical range is very considerable, including Europe, North Asia, North Africa, and the greater part of North America. We have also the White-tailed Eagle (*Haliaëtus albicilla*). The Crowned Harpy (*Harpyhaliaëtus coronatus*) is a crested eagle, widely distributed in South America.

A familiar example of the smaller eagle-like birds is the rapacious Sparrow-Hawk (*Accipiter nisus*), which is common in the well-wooded parts of Britain. Long-legged and slender in its proportions (fig. 120), this bird is otherwise not unlike a falcon as regards the character and markings of the plumage, but is distinguished by shorter wings, more gently curving beak devoid of notches at the side, and a peculiarly dashing flight. The female Sparrow-Hawk destroys more game than any other native bird of prey. As to range, this form extends throughout Europe, North Asia, and North Africa, while allied species are found in most parts of the globe.

The other eagle-like birds of Britain are:—Common Buzzard (*Buteo vulgaris*); Rough-legged Buzzard (*B. lagopus*); Marsh Harrier (*Circus æruginosus*); Montagu's

RÜPPEL'S VULTURE (*Gyps Rüppeli*)

This powerful bird is an inhabitant of the Western Soudan. Its strong hooked beak and well-developed talons show it to be a bird of prey, while the bare neck is characteristic of the group of Vultures to which it belongs. In tropical countries dead animals begin to putrefy very rapidly, and would constitute a serious nuisance were there not some natural provision for their speedy removal. Vultures are typical scavengers; the bare necks of these creatures are an obvious adaptation to their nauseous but useful habits.



RÜPPEL'S VULTURE (GYPS RÜPPELI)

A STUDY FROM THE LIFE

Harrier (*C. cineraceus*); Hen Harrier (*C. cyaneus*); Kite (*Milvus ictinus*); Osprey (*Pandion haliaëtus*); Honey Buzzard (*Pernis apivorus*).

Vultures.—Here are included large birds which for the most part feed on carrion, and therefore play an important part in nature as scavengers, in accordance with which habit the head and neck are as a rule devoid of plumage, or only provided with short stiff feathers. The long beak is sharply bent down at the tip, and there is a large cere. These birds are common in the warm parts of the Old World.

A well-known species is the Black Vulture (*Vultur monachus*), which ranges from the European and African shores of the Mediterranean to India and China in the east. Its beak is black, like its plumage, while the bare head and neck are flesh-coloured, the latter being further distinguished by a peculiar ruff of feathers, as commonly is the case in birds of the group. Another typical form is Rüppel's Vulture (*Gyps Rüppeli*), a native of North Africa.

Fig. 120.—Sparrow-Hawk (*Accipiter nisus*).

American Vultures differ in a number of respects from those of the Old World, as particularly in the absence of a syrinx (the organ of voice specially characteristic of birds), and the lack of a partition between the right and left nostrils. To this group belongs the largest of living flying birds, the Condor (*Sarcorhampus gryphus*) of the Andes, in which the spread of the wings may be as much as 9 feet. The shining black plumage is relieved by a white neck-ruff, and by white and grey shading on the wings. In the male there is a fleshy outgrowth or wattle on the top of the head. These birds, though mainly carrion feeders, also prey on living animals.

Secretary-Birds.—The only representative of the last group of diurnal birds of prey is the well-known Secretary-Bird (*Serpentarius secretarius*), which ranges from South Africa far north along both sides of the continent. In general appearance it looks like a modified eagle mounted on stilts, and may exceed 4 feet in height. The naturally long tail is made still longer by the great extension of its middle pair of quills, and projecting backward from the head on each side is a loose crest which, suggesting a bundle of quill pens carried above the ear, has given rise to the popular name. The plumage on the head, neck, and front part of the body and wings is mostly light-grey, but the top of the head, with the crests, the quills (except the middle pair of the tail), the abdomen, and the tops of the legs, are much darker in hue.

Secretary-Birds feed on reptiles, small mammals, and game-birds.

Order 13.—Ducks, Geese, and Flamingoes (Anseres)

In this large order the large bill is usually broad and flattened, and the three front toes are united by a web. The young are "precocious", *i.e.* able to run about and feed themselves almost at once, as is familiarly illustrated by the case of the duckling. Species belonging to the order are found in all parts of the world.

Ducks and *Geese.*—These are short-legged birds with broad straight bills and smooth plumage which easily sheds the water. They are essentially adapted to an aquatic life, and their clumsy movements on land are familiar to all. A common type is the British Wild Duck (*Anas boschas*), from which our domesticated varieties are derived. The brilliant colouring of the drake is too familiar to need description. This species ranges over the whole of the Northern Hemisphere. *Shoveller Ducks* are distinguished from other ducks by the peculiar shape of their unusually large bills. The Common Shoveller (*Spatula clypeata*) is a winter visitor in Britain. Among other British ducks, Teal (*Querquedula quetta*), Widgeon (*Mareca penelope*), and Eider Ducks (*Somateria mollissima*) may be mentioned here.

The remaining native ducks are:—Pintail (*Dafila acuta*); Tufted Duck (*Fuligula cristata*); Pochard (*F. ferina*); Golden-eye Duck (*F. glaucion*); Scaup (*F. marila*); Ferruginous Duck (*F. myroca*); Long-tailed Duck (*Harelda glacialis*);

Smew (*Mergus albellus*); Goosander (*M. merganser*); Red-breasted Merganser (*M. serrator*); Velvet Scoter (*Œdemia fusca*); Black Scoter (*Œ. nigra*); Sheldrake (*Tadorna cornuta*).

Geese are heavier and clumsier birds than ducks, and there is a curious knob on the tip of the bill. The domestic form is in all probability descended from the Grey-lag Goose (*Anser cinereus*) (fig. 121), which breeds only in Britain, and ranges from our islands throughout Europe and as far east as China. The Egyptian Goose (*Chenalopex Ægyptiacus*) was domesticated by the ancient Egyptians, who much appreciated it as an article of diet, as is attested by sculptures.

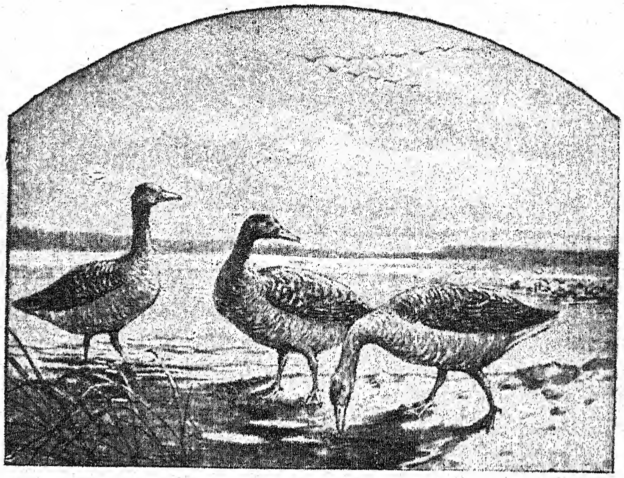


Fig. 121.—Grey-lag Goose (*Anser cinereus*)

Other British geese besides the Grey-lag are:—White-fronted Geese (*Anser albifrons*); Pink-footed Geese (*A. brachyrhynchus*); Bean Geese (*A. segetum*); Brent Geese (*Bernicla brenta*); Bernicle Geese (*B. leucopsis*).

Swans are large birds related to the geese, but distinguished by their long slender necks and shorter bills. The common White or Mute Swan (*Cygnus olor*) is distributed through Europe, and also ranges into Asia and North Africa. We have also Bewick's Swan (*C. Bewicki*) and the Whooper (*C. musicus*). Remarkable species as regards colour are the Black Swan (*Cygnus atratus*) of Australia and the Black-necked Swan (*Cygnus nigricollis*) of the southern parts of South America.

Flamingoes are large birds which give a general impression of swans mounted on storks' legs, but are peculiar in regard to the beak, which is very large and bent sharply downwards for the greater part of its extent. The species are not very numerous, but have a wide distribution, being absent, however, from the colder regions of the globe and from Australia. The Common

Flamingo (*Phœnicopterus roseus*), like all its allies, is distinguished by the prevailing red colour of the plumage, the predominant shade in this case being rose-pink relieved by the black wing-quills and scarlet wing-coverts. The black-tipped beak is otherwise rose-coloured, as are the legs and feet. This particular species ranges from the south of France and Spain eastwards to Siberia and India, and southward to the Cape.

Order 14.—HERONS and STORKS (Herodiones)

The birds of this order are long-legged waders with powerful wings and long strong pointed beaks. The feet are either not

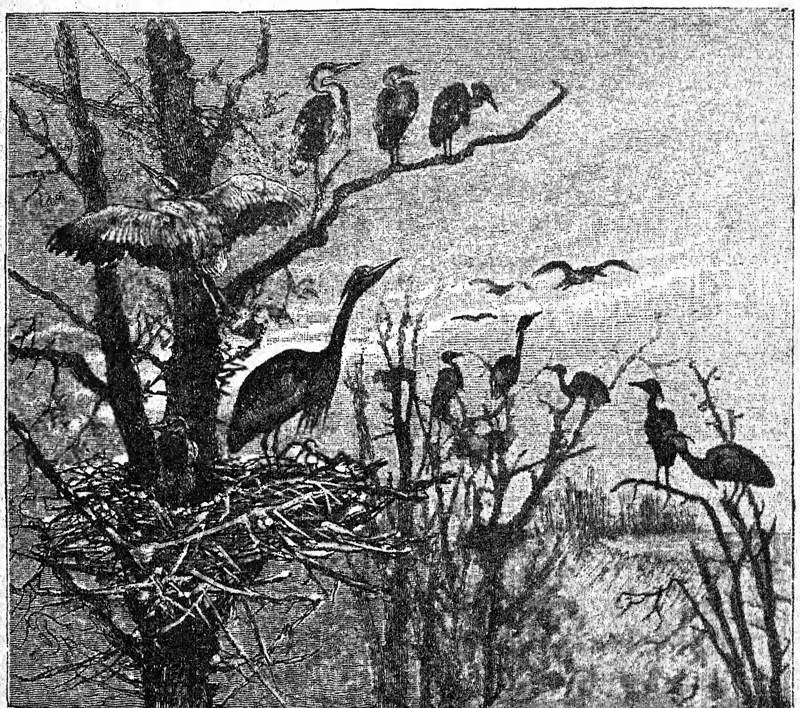


Fig. 122.—Herons and their Nests

webbed at all or only partially so, and in the latter case the great toe is always free. The order includes the groups of herons, storks, and ibises.

Herons (fig. 122).—These are slenderly-built birds with narrow beak, and in most cases a slender neck. The wings are large but blunt-tipped, and there is a curious patch of "powder

down" feathers on each side of the rump, *i.e.* of downy feathers the tips of which readily crumble into powder. The plumage is somewhat loose, and the head or adjacent parts are often crested. Herons are mostly found in marshy places, preying upon fish, or it may be other small animals. Though commonest in tropical and subtropical regions, they are also widely distributed elsewhere, and are best known in Britain as represented by the Common Grey Heron (*Ardea cinerea*), the unfortunate bird which was the chief victim of the ancient sport of falconry. This species ranges eastwards to Japan, and southwards to the Cape. Bitterns and Boat-billed Herons are other members of the group.

Besides the Grey Heron, we have in Britain:—Common Bittern (*Botaurus stellaris*); Little Bittern (*Ardetta minuta*); Night Heron (*Nycticorax griseus*).

Storks.—These are not so slenderly built as herons, and do not possess the patches of powder-down feathers. The three front toes are connected together at their bases by a small web. Like herons, they haunt swamps and inland waters, feeding largely on frogs, and their distribution is equally wide.

The White Stork (*Ciconia alba*) is found in most parts of Europe, from which it ranges into North Africa, Central Asia, and India. This bird is a familiar object on the Continent, enjoying for the most part immunity from human attack, and nesting on chimneys, the gable-ends of buildings, &c. It plays a large part in fairy tales and stories, as everyone knows who has read "Andersen's Fairy Stories", and who has not? All will remember that the Stork is supposed to bring the new brothers and sisters, as witness the story of the irreproachable Peter, whose invocations to this invaluable bird were rewarded by the appearance of a brother and sister at the same time. Closely related to ordinary storks are the large, ungainly Adjutants or Marabout Storks of Africa and India, with enormous bills. They feed not only upon small living animals, but also on carrion, and in accordance with this habit the head is destitute of ordinary feathers.

Ibises.—Smaller than the average members of the preceding groups, these birds possess beaks which are only hard at the tip. Their wings are pointed and their tails abbreviated. In habits and distribution they are very similar. The best-known species is the African Ibis (*Ibis Æthiopica*) (fig. 123), which

was venerated and embalmed by the ancient Egyptians, and which, with its long curved beak and bald black head and neck contrasting with the generally white plumage, is a striking object. Its head-quarters are now the upper waters of the Nile, from which it ranges with diminishing numbers to Cape Colony. A beautifully-coloured form is the Scarlet Ibis (*Guara rubra*) of tropical America and the West Indies, in which the plumage is bright scarlet except the wing-tips, which are black.

Fig. 123.—African Ibis (*Ibis Æthiopica*)

The widely distributed *Spoonbills* are closely related to the Ibises, but are distinguished by the peculiar form of the broad straight beak, which widens out into a rounded end. The White Spoonbill (*Platalea leucolodia*) is a common European bird which also ranges into North Africa and eastward to India and North China. It is but rarely seen in our own country. The beak and legs are black and the plumage prevailingly white.

Order 15.—Pelicans and Cormorants (Steganopodes)

This order of swimming birds includes short-legged forms in which all four toes are well developed and connected together by a web. The wings and tail are large, and the organization is adapted for the pursuit of fish. Four groups are here included: Pelicans, Cormorants, Frigate-Birds, and Tropic-Birds.

Pelicans.—These well-known birds are distinguished by their enormous flattened beaks, to the lower half of which is attached a large pouch in which fish can be stored. "Feeding time" with the Pelicans is one of the favourite spectacles of interest

at the Zoo. The group is widely distributed in the warmer parts of the globe, and its members haunt the banks of rivers and the neighbourhood of swamps. The best-known species is the European Pelican (*Pelecanus onocrotalus*), which is found not only in South Europe, but North Africa, and also in parts of West Africa.

Cormorants.—These are smaller birds than the pelicans, and are characterized by their long bodies and necks and the possession of a moderately long beak, rather narrow, and hooked at its tip. Both face and throat are bare of feathers. Cormorants are excellent divers and swimmers, and their greediness is extreme. Two species are well known in British seas. One, the Black Cormorant (*Phalacrocorax carbo*), has an extraordinarily wide range, including all Europe, North Africa, most of Asia, and the Atlantic shores of North America. The other British species is the Green Cormorant or Shag (*P. graculus*). The Chinese and Japanese train cormorants to fish for them, and, until properly trained, a ring is put round the neck to prevent the captures from being swallowed.

Other birds related to the cormorants are *Gannets* and *Darters*. Of the former the most familiar type is the Common Gannet (*Sula bassana*), found on the coasts of the northern seas, and breeding in vast numbers at one locality on the east coast of Britain, the Bass Rock. The Scottish name for this bird is the Solan Goose, a name which suggests its general appearance, though about the neck and head it is much more like a cormorant. The head and neck are buff-coloured and the wing-tips black, but otherwise the plumage is white. The "boobies", so named from their fearlessness, of which we read in accounts of voyages to southern seas, are closely allied to gannets.

Darters or *Snake-Birds* are a small group with exceedingly long flexible neck, small head, and long, extremely sharp-pointed beak. The legs are attached far back to the elongated body. These forms haunt the inland waters of South America, Africa, India and Further India, and Australia.

Frigate and *Tropic Birds* are both distinguished by their pelagic habits, *i.e.* they are commonly found in the open sea at great distances from land. Each group contains but a single genus, and the distribution is similar, as both of them are found in the warmer parts of the Atlantic, Pacific, and Indian Oceans.

The Great Frigate-Bird (*Fregatus aquila*) is a striking object, with its long, hooked beak, powerful wings, and forked, swallow-like tail. The legs are extremely short, and feathered to the toes, which have but an imperfect web. The dark plumage of the male is relieved by a bright-reddish throat. Tropic-Birds are well known from their habit of following ships. They are

Fig. 124.—Albatross (*Diomedea exulans*)

small and light-hued, differing from Frigate-Birds in the shape of the beak, the complete webbing of the toes, and the nature of the tail, of which the two middle quills are much elongated. The commonest species is the Red-beaked Tropic-Bird (*Phæthon æthereus*), prevailingly white in colour, but with a coral-red beak.

Order 16.—Petrels and Albatrosses (Tubinares)

The birds of this order are good swimmers, and have webbed feet not unlike those of the next two orders. They are essentially marine, and have a wide distribution, being commonest, however, in the seas of the southern hemisphere. The members of the group are distinguished by being "tube-nosed", *i.e.* the nostrils

open upon a pair of forwardly-directed tubes. All are powerful flyers, and their food consists of fish, various small marine animals, and refuse of various kinds. The strong beak, with sharp, hooked tip, is well adapted to the carnivorous habit.

The Wandering Albatross (*Diomedea exulans*) (fig. 124), distinguished by its enormous spread of wing (10 to 12 feet), and

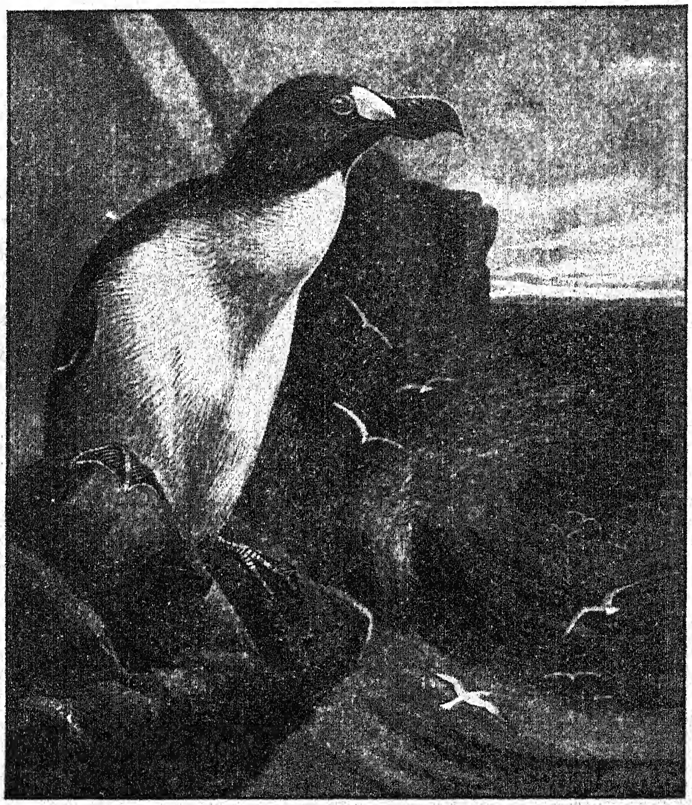


Fig. 125.—Great Auk (*Alca impennis*)

found chiefly in southern seas, is immortalized in Coleridge's *Ancient Mariner*. Almost as well known is the Storm Petrel (*Procellaria pelagica*) of the North Atlantic, called "Mother Carey's Chicken" by sailors. It is only 6 inches long, and is the smallest web-footed bird found in British seas.

Order 17.—Divers and Grebes (Pygopodes)

The diving birds are distinguished by the modifications they have undergone to enable them to pursue fish. In accordance

with this, the short legs are attached to the body extremely far back, and the feet are either webbed or the toes are broadened out into lobes. As in a pigeon, there are three forwardly-directed digits, but the great toe, instead of being well-developed, is either small or absent, not being required in birds which are not in the habit of perching on branches and the like. The wings are comparatively short, and are useful not only as organs of flight, but to assist the animal in swimming. The straight beak is more or less flattened from side to side. Auks, Divers, and Grebes are included in this order. Of the first group perhaps the most interesting is the Great Auk, or Gare-Fowl (*Alca impennis*) (fig. 125), which is unfortunately extinct, the last specimens having been shot in 1844. It formerly occurred in great numbers on some small Icelandic islands, and Funk Island, near Newfoundland, to which localities it largely resorted for breeding purposes. Its small wings were useless for the purposes of flight, a fact which had much to do with its extinction. All the remaining flightless birds are limited to the southern hemisphere. The nearest living relative of the Great Auk is the Common Razorbill (*Alca torda*) (fig. 126), which is common in British seas and has a wide range along both shores of the North Atlantic. Near the Auks come the *Guillemots*, with narrower and straighter beaks. The type form is the Common Guillemot (*Uria troile*), which has a similar distribution to the Razorbill. Much more peculiar forms are the *Puffins*, called "sea parrots" from the shape of their exceedingly large and laterally-compressed bills. The Common Puffin (*Fratercula arctica*) is the only kind found in British waters, and has a winter range from the Arctic regions to the Tagus on the eastern shore, and to New York on the western shore, of the Atlantic. The orange-coloured beak, shading into red at the tip, and the white plumage covering the breast and sides of the head, make this bird a conspicuous object.

Other British Auks are:—Little Auk (*Mergulus alle*); Black Guillemot (*Uria grylle*).

The *Divers* differ from the auks in several particulars, the most obvious of which is found in the greater length and sharpness of the beak. The Great Northern Diver (*Colymbus glacialis*), which ranges from the Arctic regions to the Mediterranean and is not infrequent on British coasts, is distinguished by its black head,

throat shaded with black and white, and dark back crossed by rows of white flecks. The under side is white, as in so many birds and other animals.

There are two other British Divers:—Black-throated Diver (*Colymbus arcticus*); Red-throated Diver (*C. septentrionalis*).

Grebes resemble the preceding groups in many respects, but their toes are expanded into lobes instead of being webbed, and

Fig. 126.—Razorbills (*Alca torda*)

the tail is very small, and provided with a downy tuft instead of the usual quills. The plumage of Grebes is much used for ornamental purposes, and its beauty is mainly due to the silky white feathers which cover the breast.

The most familiar member of the group in Britain is the Dabchick or Little Grebe (*Podicipes fluviatilis*), a bird which has a very wide range and is common on rivers and ponds.

Other Grebes which occur in British waters are:—Slavonian Grebe (*Podicipes auritus*); Great Crested Grebe (*P. cristatus*), Red-necked Grebe (*P. griseigena*); Eared Grebe (*P. nigricollis*).

Order 18.—PENGUINS (Impennes)

Penguins are web-footed birds with reduced great toe, resembling the divers in a number of particulars, but still better adapted to an aquatic life, as is seen especially in the wings, which are useless for the purpose of flight and are transformed into flippers covered with very numerous scale-like feathers. The hind-limbs, in which the tarso-metatarsal region is unusually short, are fixed to the body very far back, and the small tail, unprovided with efficient quills, serves as a prop by which the body is steadied in the upright position which is habitual on land. The long, straight beak, somewhat flattened laterally and with a sharp point, is well adapted for seizing and holding the fish which constitute the chief food. Penguins have a very wide range along the shores of the continents and islands south of the equator, flocks of them being abundant even on the desolate Antarctic coast. Few birds, if any, are so remarkable in appearance, and they have attracted the attention of all travellers in southern seas.

As examples may be taken the Emperor Penguin (*Aptenodytes Forsteri*) of the Antarctic regions, which is about 3½ feet high; the King Penguin (*Aptenodytes Pennanti*) (fig. 127) of Kerguelen Land; and the Blue Penguin (*Eudyptula minor*) of South Australia and New Zealand, which is less than half that size.

II. RUNNING BIRDS (Ratitæ).—These birds, of which the most familiar form is the African ostrich, are mostly large, while all are flightless, this being to some extent compensated by the possession of unusual powers of rapid progression on the ground. The group is essentially one belonging to the southern hemisphere.

Inability to fly is associated with a number of structural features, foremost among which is a great reduction in the size of the wings. There are also a number of characteristic features about the plumage, which is not arranged in definite tracts as in flying birds (see p. 142). The quills, which in ordinary birds play such an important part in flight, are here much reduced, and the barbules of the feathers are not connected together by hooklets. The vertebræ of the tail are not fused together into a ploughshare-bone as in flying birds, there being no efficient tail-quills to support. The name of the group (Lat. *rates*, a raft) has reference

to the absence of a keel on the broad sternum. It will be remembered that the keel in an ordinary bird (p. 145) serves for the attachment of the large muscles of flight. There is no "merry-thought", while the scapula and coracoid are in the same line with one another instead of being at an angle. The overlap-

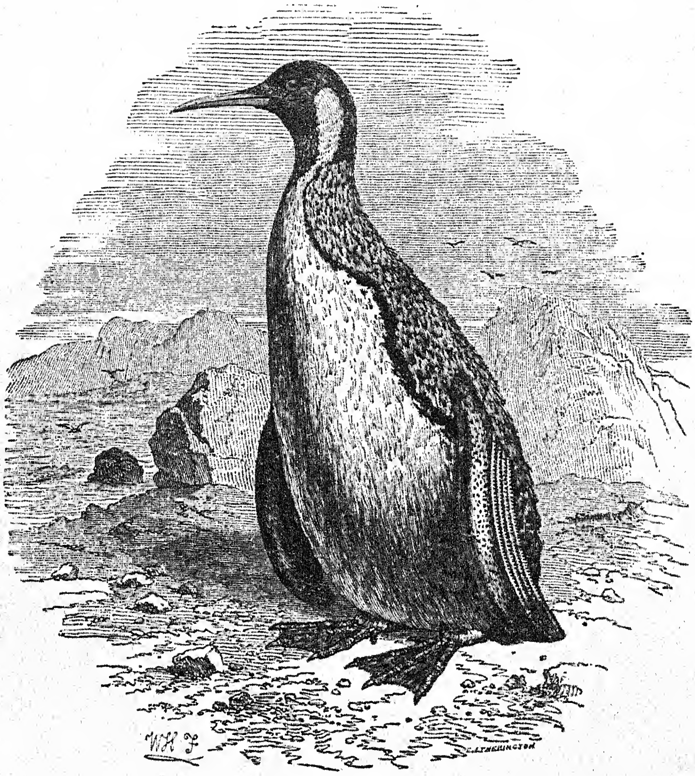


Fig. 127.—King Penguin (*Aptenodytes*)

ping uncinate processes, which in a flying bird help to strengthen the chest, are here absent or few in number.

The strong legs are well adapted for running, and in nearly all cases there is a reduction in the number of toes.

The structure of these birds is best explained on the assumption that they are descended from carinate birds in which the power of flight has been lost, and their nearest relatives are probably the Tinamous.

The Ratitæ which are now living may be divided into African Ostriches American Ostriches, Cassowaries and Emeus, and Kiwis.

African Ostriches are distributed through the deserts of Africa, and also range into Arabia and Syria. The small flat head is provided with a strong, broad beak, capable of being opened very widely, and large eyes surrounded with small bristly feathers resembling eyelashes. Both the head and the long neck are covered with long fluffy feathers. The legs are immensely powerful, and are used as weapons as well as for locomotion. Only two toes are present—the third and fourth, the former being much the larger, and there is a soft pad on the under side of each, much as in a camel. The plumage of the female is grey, that of the male black, except the wings and tail, which are pure white. There are no after-shafts to the feathers. The nest is simply a hollow made in the sand, and several hens lay their yellowish-white eggs in it. The work of incubation is almost entirely done by the male.

There are apparently several species of ostrich, the most familiar one (*Struthio camelus*) being distinguished by its red neck, while an East African form has a bluish neck, and this region is grey in a smaller kind from South Africa.

American Ostriches or *Rheas* are only found in South America, and can be distinguished at once by the presence of three toes, less modified than those of the African form, feather-covered head and neck, larger wings, and no tail. In structure (including the absence of after-shaft) and habits they resemble in most points the African forms, and their eggs are of similar colour. The plumage is grey, and both sexes closely resemble one another in this respect.

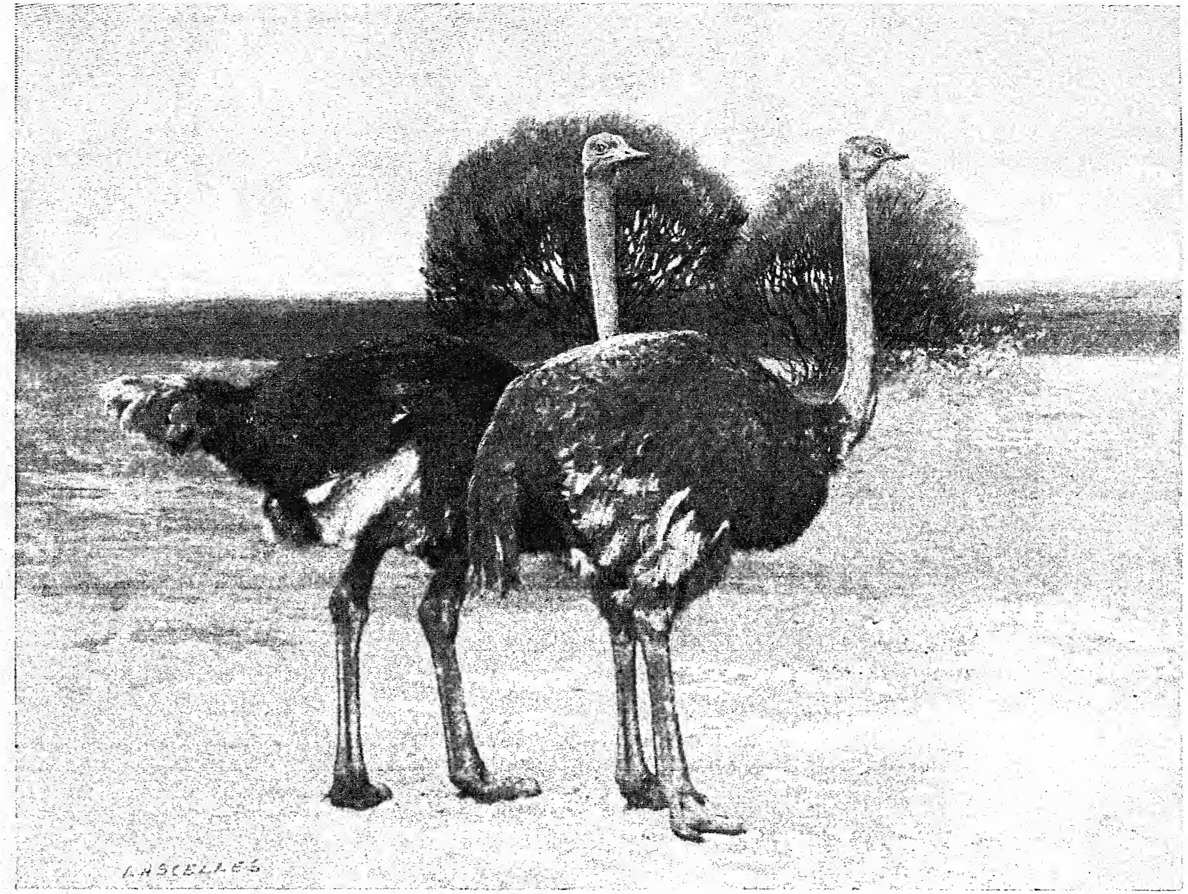
Three species are recognized, of which the Common Rhea (*Rhea Americana*) is largest and best known. It is commonest in the pampas region of the Argentine Republic, ranging north to Bolivia and south to the Rio Negro. Darwin's Rhea (*Rhea Darwini*) is found from the east of Patagonia to some distance north of the above-named river, while the Long-billed Rhea (*Rhea macrorhynca*) is limited to North-east Brazil.

Cassowaries and *Emeus* are to be regarded as the ostriches of the Australian region. They agree with the rheas in possessing three toes, but the wings are much reduced, the feathers appear double from the presence of very large after-shafts, and the eggs are green and rough.

The Emeu (*Dromæus*), found only on the Australian continent

THE AFRICAN OSTRICH (*Struthio camelus*)

African Ostriches are the largest living members of the group of Running Birds (Ratitæ), all of which are restricted to the Southern Hemisphere. The South African variety represented is the one domesticated for the sake of its feathers, and is somewhat smaller than a variety which lives farther north. African Ostriches possess but two toes, and this reduction is related to the specialization of the legs for the purpose of rapid locomotion. The extinct Æpyornis, of which bones and eggs are found in Madagascar, was an immense form related to the Ostrich, and possibly the prototype of the "Roc" which figures largely in Eastern tale and legend.



SOUTH AFRICAN OSTRICHES (STRUTHIO CAMELUS)

A STUDY FROM THE LIFE

and some of its islands, resembles an ostrich in appearance, but is shorter-necked and has a slenderer body. The feathers of the head and upper part of the neck are very small, and the plumage generally is very loose, the feather barbules being widely separated. Unlike ostriches, these birds are monogamous, but, as in them, incubation is carried on by the male. The young birds are striped.

Cassowaries (*Casuarius*) (fig. 128) are restricted to North

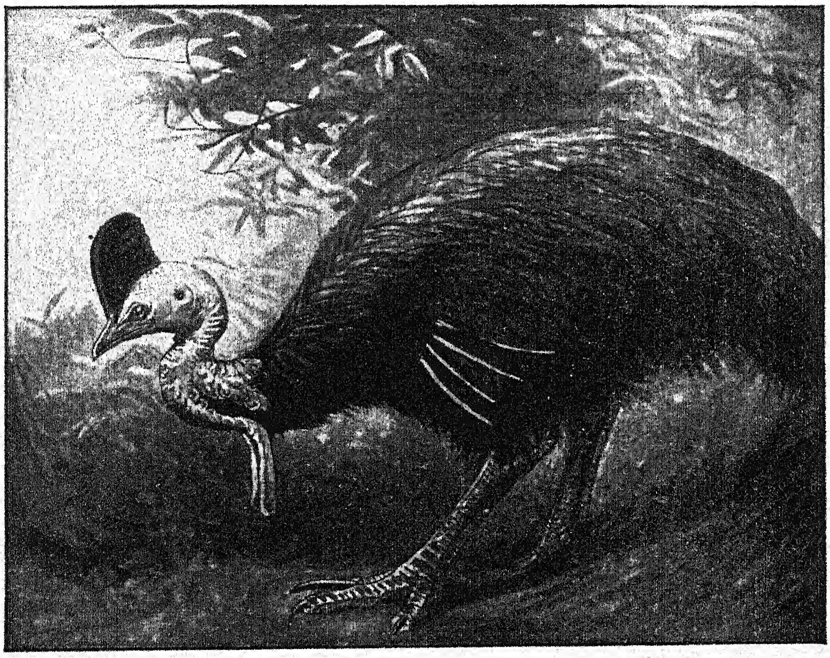


Fig. 128.—Cassowary (*Casuarius*)

Australia, Ceram, New Guinea, and adjacent islands. Their appearance is very striking, and in some respects they are the most modified of all the running birds. The head and upper part of the neck are bare and brilliantly coloured—blue, red, green, or yellow, according to the species. In some cases there are fleshy outgrowths or wattles on the neck. The beak is not unlike that of an ordinary fowl in shape, and there is a peculiar "casque" on the top of the head, formed by an outgrowth from the skull. The shining plumage is bluish-black, and resembles hair in texture rather than feathers. The small wing bears four or five quills, represented, however, only by their shafts. Feathers

extend down to the ankle-joints of the legs, which are characterized by the further feature that the innermost toe bears a claw twice as long as those on the other toes.

Unlike the other ostrich-like birds, they inhabit forest-regions. The nesting habits, so far as known, resemble those of the emeu.

The *Kiwis* (*Apteryx*) (fig. 129) are New Zealand birds of remarkable appearance, and much smaller than the preceding forms, being about the size of a hen. The reduction of wings and tail is greater than in the other running birds, and their plumage is more hair-like, peculiarities which confer a certain grotesque resemblance to a man with his hands in his pockets. Two marked characters at once distinguish them from the ostrich-like forms of the same group. One is the slender snipe-like beak at the end of which the nostrils are situated. The other is found in the presence of the first toe. The legs are very strong, and all four toes are provided with powerful claws. At the base of the beak are a number of long whisker-like feathers. Kiwis are nocturnal birds, and resemble the emeu and cassowary in their nesting habits. The cream-coloured eggs are of relatively enormous size, being about 5 inches in length.

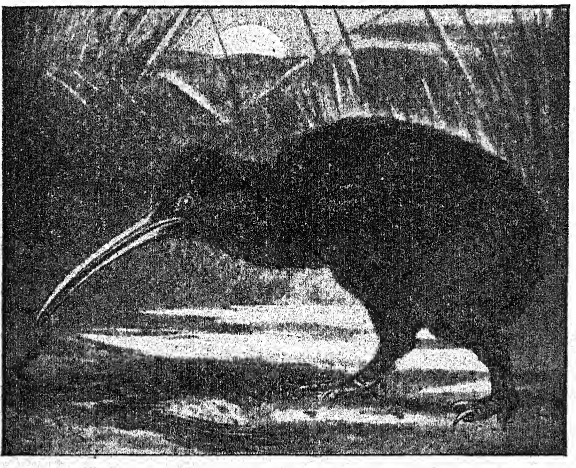


Fig. 129.—Kiwi (*Apteryx*)

CHAPTER IV

STRUCTURE AND CLASSIFICATION OF REPTILES

The two great groups of Backboned Animals so far considered, *i.e.* Mammals and Birds, are both characterized as "warm-blooded", for the animals included possess hot blood which is maintained at a practically constant temperature independently of external conditions. This peculiarity is associated of necessity with very perfect breathing arrangements (see pp. 45 and 147), and results in great activity and high intelligence.

Contrasted with these two high groups we have the Reptiles and still lower forms, which are "cold-blooded", in the sense that the blood is of the same approximate temperature as the surrounding medium—air or water, as the case may be—and is therefore hot in hot weather and cold in cold weather. Such animals, as compared with Mammals or Birds, are in the main sluggish, and not remarkable for intelligence.

Reptiles are a very ancient group, and probably form the stock from which both Mammals and Birds have been derived, on which subject more will be said in another section of the book. Reptiles preceded Mammals as the dominant Vertebrates both on sea and land, and many remarkable groups once existed which are now entirely extinct. Recent Reptiles include crocodiles, lizards, turtles, and snakes, with their respective allies. The most average forms are probably *Lizards*, of which there are three British species, and a brief description of the most typical of these will be an appropriate introduction to the study of Reptiles in general.

The Sand Lizard (*Lacerta agilis*) is commonly to be found on sunny slopes in this country, and appears to be especially abundant where the soil is of a sandy nature. When thoroughly warmed by basking, it is capable of moving with considerable rapidity, hence the specific name *agilis*. Average specimens are not more than 5 or 6 inches long, but this length is sometimes exceeded by 2 or 3 inches.

External Characters.—The flattened triangular head, with blunt forwardly-directed apex, is separated by a short ill-marked neck from the long rounded trunk, and this again passes into a very long slender tail. The shape is well adapted to the darting movements by which the animal makes its way through heather and grass. The limbs are short and primitive-looking: they are divided into the same regions which we have found to be typical for Mammals (p. 24) and Birds (p. 140); *i.e.* upper arm, fore-arm, and hand for the front-limb, corresponding to the thigh, lower leg, and foot in the hind-limb. There are five fingers and five toes, all ending in claws, and the shortest digits in their respective limbs are the thumb and great toe. The body is not lifted well off the ground by the limbs, and this is not because these are short, but owing to their "sprawling" arrangement, knee and elbow projecting outward, instead of being brought well below the trunk, as in a dog, cat, or other Mammal.

Returning to the head, the flatness of which as compared with a Bird is due to the relatively small brain, we note a large mouth extending far back from the front end of the snout, near the tip of which can be seen the two small nostrils. Further back come the good-sized eyes, which, as in a Bird, are provided with a nictitating membrane (p. 140), as well as with upper and lower eyelids. Some little distance behind either eye, not far from the angle of the mouth, is an auditory aperture, devoid, as in Birds, of an external flap or pinna. Here, however, the external passage of the ear (external auditory meatus), which leads down to the tympanic membrane, is excessively short, so that the membrane is brought close to the surface, and can readily be seen without dissection.

The only other aperture of importance is that of the cloaca (p. 146), a transverse cleft on the under side of the trunk where it passes into the tail.

While Mammals are distinguished by the possession of hair, and Birds by their feathers, Reptiles have an exoskeleton of scales, which, like hairs and feathers, are products of the outer layer of the skin, or epidermis. Bony plates, or bony scutes formed in the deeper part of the skin (dermis), may be present as well. The scales of the Sand Lizard are very obvious structures with a definite arrangement. Those on the head are comparatively large, and it has been found convenient to give some

of them special names, as their arrangement is constant for a given species, and is therefore an important aid to classification. The scales on the upper side of the trunk are small, but those on its under side are much larger, and arranged in longitudinal rows, while those of the tail are also of a good size, and arranged in regular encircling rings.

The colour of the Lizard harmonizes with its surroundings, and this "general resemblance" is both "protective" and "aggressive", as it renders the animal inconspicuous as well to its own foes as to the insects upon which it preys. The ground colour of the male is greenish on the upper side, shading into lighter colour below; but in the female duller tints of grey or brown predominate. Both sexes are darkly marked on the upper side, there being an especially well-marked stripe running down the middle of the trunk.

Endoskeleton (fig. 130).—The same regions are present as in a bird, but though there are many points of agreement there are numerous differences, partly due to the great peculiarity of the bird. The lizard's bones do not contain the air-cavities which are so often found in birds.

In the *skull* the brain-case is much smaller in proportion than in a bird, a fact directly related to the relative size of the brain in the two animals. With few exceptions the bones of the skull are the same as in the bird, but the boundaries between them remain fairly distinct in the adult, instead of fusing together so as to obliterate all boundaries. There is one occipital condyle (see p. 28), or rounded prominence for union with the backbone, each half of the lower jaw is made up of several pieces, and the presence of a movable quadrate bone enables the mouth to be opened very widely (see p. 143): all points of agreement with Birds and difference from Mammals. An interesting peculiarity is found in the presence of a small hole, the *parietal foramen*, in the top of the brain-case. Imbedded in the floor of the mouth, and giving attachment to the muscles of the extremely mobile tongue, is the gristly "hyoid apparatus", made up of a central pointed portion, from which three slender rods run out on each side.

The *backbone* consists of a large number of vertebræ, and is fairly flexible throughout, exhibiting neither of the extremes which characterize the Pigeon (see p. 144). The usual regions can be made out, except that it is not possible to say where the thoracic

vertebræ end and the lumbar ones begin, and the numbers are as follows:—Cervical, 8; thoracic and lumbar together, 22; sacral, 2; caudal, very numerous, but of no constant number. The ends of the centra or bodies of the vertebræ are neither flat as in Mammals nor saddle-shaped as in Birds, but concave in front and convex behind, or, technically speaking, *procœlous*. This is the commonest arrangement among recent reptiles. The first two joints of the neck are constituted by atlas and axis as in a Mammal (see p. 26) or Bird; but the odontoid peg which projects forwards from the front end of the latter is never fused with, though firmly fixed to, it. The peg is in reality a bit of the atlas centrum which has been appropriated by the axis for the purpose of making a pivot. There are two interesting peculiarities about the tail, one of which consists in the presence of small Y-shaped bones united to the under sides of many of the caudal vertebræ, the stem of the Y being directed downwards. In this way a canal is formed in which the great blood-vessels of the tail are sheltered, an arrangement which is found in various groups of backboned animals. Another and more interesting peculiarity is found in the fact that the body of almost every vertebra in this region remains unossified, *i.e.* is not of bony nature, across a narrow central strip. The tail of a lizard is extremely brittle, partly as a result of the arrangement described, and this would appear to be a defensive provision, whereby, supposing the animal to have been attacked in the rear by an enemy, a part is sacrificed to save the rest.

Slender curved *ribs* are attached from the fourth neck-vertebra right back to the sacrum, and, as elsewhere, the first thoracic vertebra is taken to be the one bearing the first rib that is connected with the sternum. Only five pairs are so connected in the Sand Lizard, the means of union being slender gristly *sternal ribs*, by which the bony *vertebral ribs* are continued in the downward direction (see p. 29). Each of the two sacral vertebræ possesses a strong transverse process on each side, by which attachment to the hip-girdle is effected, and it has been shown that these processes ossify or become bone independently of the bodies of these vertebræ, fusing with them subsequently. On this account the processes are looked upon as ribs which have united with the vertebræ to which they belong—a phenomenon which is paralleled elsewhere.

The *sternum* is an insignificant lozenge-shaped piece of cartilage, running back behind into a couple of slender rods, with which the hinder sternal ribs are united, while the others connect with the two posterior sides of the lozenge.

Skeleton of Limbs.—This is in many ways interesting, being to a large extent of what is called "generalized type", an expression which deserves a little examination, as it embodies an important idea constantly recurring in biological works. It often happens that in examining a series of human contrivances designed to meet the same or a similar end, a kind of general plan or similarity will be found to run through all of them. Under such circumstances it would very likely be possible to pick out some one of the series which might be looked upon as embodying the ideas involved in a general kind of way, and from which, by modification, the other members of the series might be derived. This case would form a *generalized type* of the entire series. A good instance is that of various kinds of habitation, of which the moderate-sized houses which make up a formal row may be taken as generalized types. In such a house would probably be found, among other apartments, breakfast-room, dining-room, drawing-room, study, and a certain number of bedrooms, all these, let us suppose, of reasonable size, and square or rectangular shape. Modifications of such an average plan might be effected in one or more of the following ways:—(1) Variation in *shape*: the dining-room, for example, might be oval or polygonal. (2) Variation in relative *size*: the drawing-room, say, might be the same size as the dining-room, or smaller, or it might be larger. (3) Variation in *number*, either on the side of increase, as by addition of a second drawing-room, or on the side of decrease, as by reducing the number of bedrooms. In the latter case a particular sort of room, perhaps the study, might be made so small as to deserve the name of a "vestige", and the next step would be its complete suppression. (4) Coalescence, or fusion of rooms, as, for instance, by complete or partial removal of the party-wall separating two adjoining rooms. By application of these principles of alteration, a small cottage on the one hand, or a castle on the other, might be referred to the same type as the average house, and it is obvious that dwellings of all styles and sizes are, after all, neither more nor less than houses or places of human habitation, and must fulfil certain average requirements. It may also be noted, in passing, that the house

illustration may be made to illustrate very well another biological principle, *i.e.* "change of function", already alluded to in the Introduction (p. 13). A room intended for a particular purpose may be, of course, used for some other purpose, as when what should be a study is converted into a nursery. An amusing case is known to the writer of a small tradesman, who, on retiring, thought of taking a house of more ambitious nature than the one that had been connected with his shop. Seeing a bath-room for the first time, he remarked that he had no use for it, and would make it a lumber-room.

Some meaning will now be attached to the expression "generalized type" as applied to the limbs of a lizard. But we may go a step further, and speak of a "theoretical type", by which is meant an arrangement so generalized that it is rarely, if ever, found in existing animals. The endoskeleton of the limbs of terrestrial vertebrates is best understood by reference to such theoretical types, which may here be conveniently explained.

As has already been pointed out (see pp. 29 and 145), the skeleton of either fore- or hind-limb consists of a girdle by which attachment to the trunk is brought about, and the skeleton of the free limb, and it has also been indicated (p. 24) that there is a correspondence or *serial homology* between fore- and hind-limb.

Girdles.—The theoretical type of *shoulder-girdle* consists of a dorsal piece, *scapula*, and two ventral pieces, the larger, *coracoid*, behind, and the smaller, *precoracoid*, in front. At the junction of the scapula with the other elements is a shallow *glenoid cavity*, to which the bone of the upper arm is attached. The *hip-girdle* consists similarly of three pieces—a dorsal *ilium*, uniting below with a ventral and anterior *pubis*, and a ventral and posterior ischium. Corresponding in position to the glenoid cavity is a somewhat deeper cup, the *acetabulum*, for the attachment of the thigh-bone.

Free Limb.—If the limb of a lizard be spread out at right angles to the body, in what is usually called the *primitive position*, and a line or axis drawn down its centre, an anterior or *preaxial* edge can be distinguished from a posterior or *post-axial* edge, and an upper or *dorsal surface* from an under or *ventral surface*. Taking first the fore-limb, we find an upper-arm bone or *humerus*, down the centre of which the axis runs, and succeeding this in the fore-arm, two bones, a preaxial *radius*, a post-axial *ulna*. Next

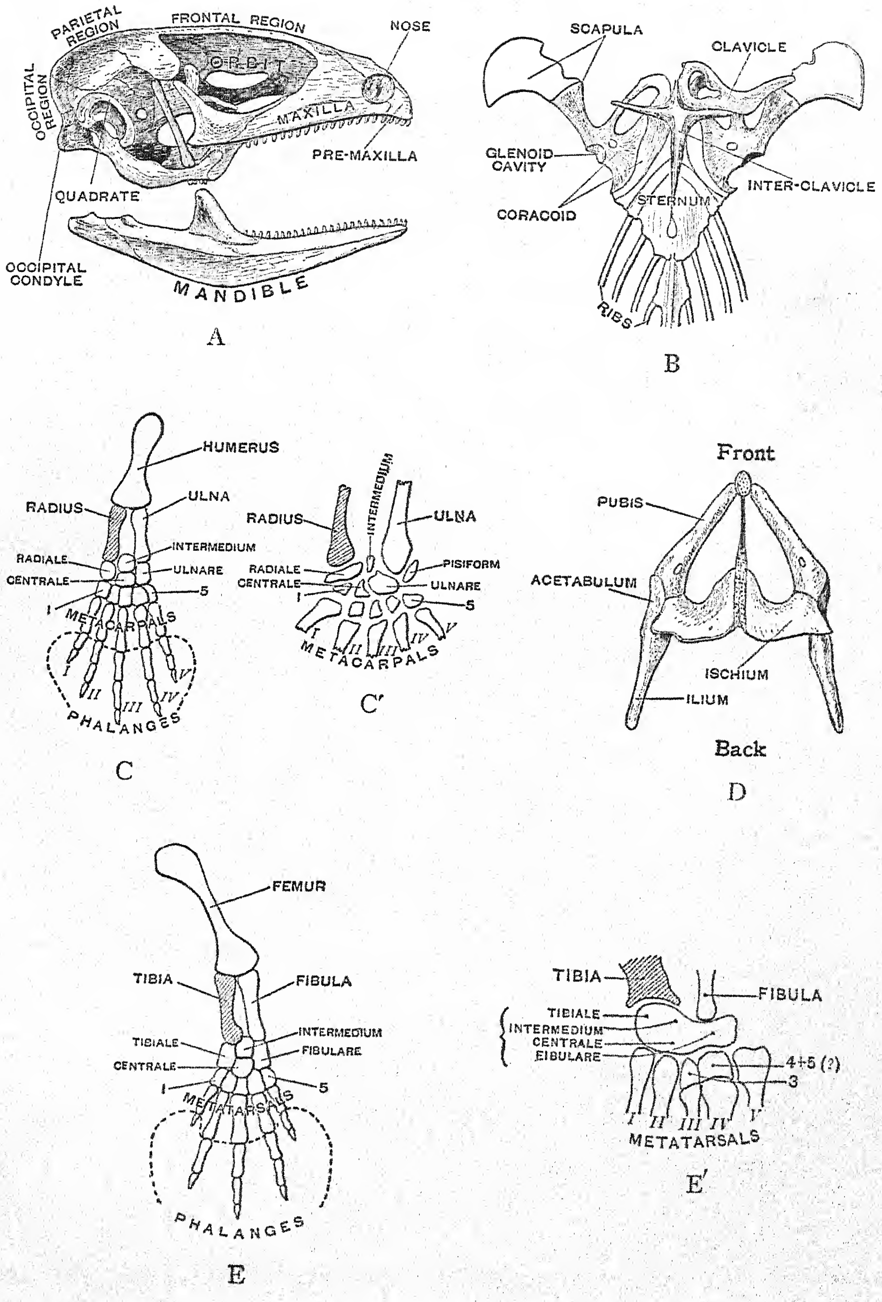


Fig. 130.—Skeleton of Lizard

A, Skull. B, Sternum and Shoulder-Girdles. C, Pattern Fore-Limb; 1 and 5, first and fifth carpalia. C, Wrist of Lizard. D, Hip-Girdles. E, Pattern Hind-Limb; 1, first tarsale, 4+5, fourth and (?) fifth tarsalia. E′, Ankle of Lizard.

comes the wrist (*carpus*), made up of a number of small elements, arranged in a near or proximal and a far or distal row. The proximal row consists of three elements—a preaxial *radiale*, so called because it is on the radial side, an *intermedium* in the middle, and an *ulnare* on the side of the ulna. The distal row of carpal elements consists of five *carpalia* for the support of the five fingers, and called, beginning on the preaxial side, carpale 1, carpale 2, &c. Wedged in between the two rows of carpal elements is a *centrale*, named from its central position. The five carpalia support the five fingers, each of which has a *metacarpal* at its base, followed by slender *phalanges*, two of these going to the thumb or first digit, and three to each of the others.

The free part of the *hind-limb* is supported by elements which correspond precisely with those of the fore-limb, as in the following table:—

Fore-Limb.	*Hind-Limb.*
1. Upper-arm bone (humerus).	1. Thigh-bone (femur).
2. Bones of fore-arm:	2. Bones of lower leg:
(*a*) Preaxial radius.	(*a*) Preaxial tibia.
(*b*) Postaxial ulna.	(*b*) Postaxial fibula.
3. Wrist (carpus):	3. Ankle (tarsus):
(*a*) Radiale, intermedium, ulnare	(*a*) Tibiale, intermedium, fibulare.
(*b*) Centrale.	(*b*) Centrale.
(*c*) Carpalia: 1, 2, 3, 4, 5.	(*c*) Tarsalia: 1, 2, 3, 4, 5.
4. Metacarpus:	4. Metatarsus:
Metacarpalia: 1, 2, 3, 4, 5.	Metatarsalia: 1, 2, 3, 4, 5.
5. Phalanges:	5. Phalanges:
Thumb, 2; other digits, 3 each.	Great toe, 2; other digits, 3 each.

If we compare the skeleton of the lizard's limbs with the theoretical arrangement just described, the result will be as follows:—

Fore-Limb—Shoulder-Girdle.—The dorsal scapular section is represented by two parts—an upper *supra-scapula* and a lower *scapula* proper, while on the ventral side both *coracoid* and *pre-coracoid* of the theoretical type are seen. But over and above this we find additional parts in the form of a slender *collar-bone* (clavicle) situated in front, and running towards the middle line to join its fellow, besides which there is a cross-shaped *inter-clavicle*, belonging to neither girdle, but coming between them, and also attached to the sternum. *Free Limb.*—Here there is a very close correspondence with the theoretical type, differences being chiefly seen in the presence of an accessory bone in the carpus coming

just outside the ulnare, and the presence of an extra phalanx in the third digit, and two extra phalanges in the fourth digit. The extra carpal bone is known as a *pisiform*, and is of different nature from the rest, for it has been developed in the course of a tendon (see p. 48), the muscle belonging to which acquires thereby a greater leverage.

Hind-Limb—Hip-Girdle.—Except in unimportant particulars we get a very close agreement with the theoretical type, all three elements—*ilium*, *pubis*, and *ischium* being present. *Free Limb.*—There is considerable departure from the simple type as regards the tarsus, the proximal part of which is represented by one element, probably representing tibiale, intermedium, fibulare, and centrale, all fused together. Only two distal elements can be seen in the tarsus; one of these is probably tarsale 3, for the third digit is united with it, while, since digits 4 and 5 both unite with the other distal elements, it perhaps may be regarded as equivalent to the two corresponding tarsalia fused together. It is not clear what has become of the first and second tarsalia. The digits are supported by the same number of phalanges as in the hand. One point is specially worthy of remark, *i.e.* the ankle-joint comes in the *middle* of the tarsus, not, as in Mammals, between the tarsus and bones of the lower leg. Such a mesotarsal ankle-joint is characteristic of both Reptiles and Birds (see p. 146).

Digestive Organs (fig. 131).—Lizards feed on insects, small worms, and the like, and possess numerous small conical teeth, and a very mobile forked tongue. The teeth are not lodged in sockets as in a Mammal, but are fixed on to the inner sides of the bones which form the margin of the upper and lower jaws. There are also two small groups of teeth on the palate. It is particularly worthy of notice that reptilian teeth, as compared with those of ordinary Mammals, are not only extremely numerous, but not divided into different kinds—incisors, canines, &c. And while a Mammal develops two sets of teeth, a Reptile has, as a rule, an indefinite succession of them, a worn-out tooth being replaced by a new one, which grows up at its base. The tongue can be protruded to some distance, and is worked by a well-developed set of muscles attached to the hyoid apparatus, the large size of which is thus accounted for.

The *digestive tube* or *gut* into which the mouth-cavity is continued consists of a *gullet*, wide slightly curved *stomach*, fairly long

coiled *small intestine*, and short wide *large intestine*, terminating in a *cloaca*. A large *liver*, provided with a *gall-bladder*, and a small *pancreas*, open into the beginning of the small intestine.

Circulatory Organs (fig. 131).—As in Mammals and Birds, we can distinguish between blood system and lymph system, of which only the former need here be considered.

Blood System.—This is a closed system of tubes, consisting of heart, arteries, veins, and capillaries, in which the cold blood circulates. Seen under the microscope, a drop of lizard's *blood*

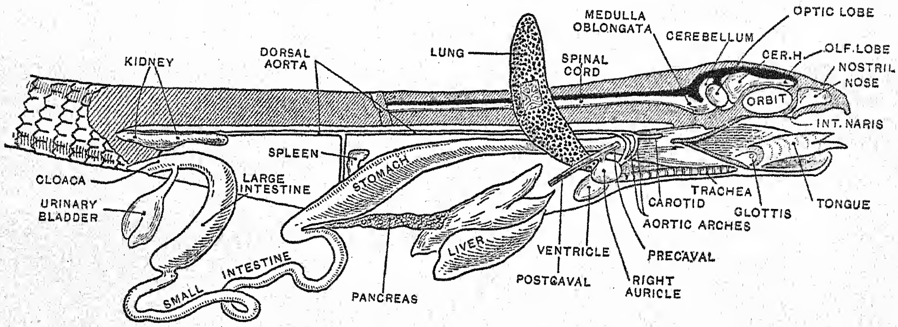


Fig. 131.—General Structure of Lizard. CER.H., cerebral hemisphere

presents much the same appearance as a drop of bird's blood, and is made up of a clear liquid plasma, in which float irregular white corpuscles capable of executing creeping movements, and oval red corpuscles, each of which is a nucleated cell.

The *heart* is enclosed in a double-walled pericardial sac, and is distinctly a more imperfect organ than in the Mammal or Bird, as, though there are two auricles, there is only one ventricle, and therefore the impure blood received by the right auricle from the body mixes to some extent with the pure blood received from the lungs by the left auricle. As will be seen, however, there are several devices by means of which the mixture of the two sorts is partly prevented.

The three great *caval veins*, two in front and one behind, bring back the impure blood to the heart, as in a Mammal or Bird (see fig. 102), but, instead of opening directly into the right auricle, they pour their blood into a thin-walled pouch, the *venous sinus*, which communicates by a valvular opening with the right auricle. As usual, the purified blood from the lungs is poured by pulmonary veins into the left auricle. The two auricles squeeze their blood through a single valvular opening into the thick-walled ventricle,

but the two kinds of blood do not mix here, for the party-wall between the auricles projects into the opening, and divides it into a right half and a left half. Although the cavity of the ventricle is single, there is a well-marked ridge protruding into it which must be regarded as an incipient partition, and actually divides the ventricle when it contracts into a right half, mostly receiving impure blood, and a left half, mainly containing pure blood. Impure blood is pumped to the lungs through a *pulmonary artery* arising from the right half of the ventricle, just as the same artery is given off from the right ventricle in a Mammal or Bird (see p. 40 and fig. 102).

A notable peculiarity here deserves mention. In a Mammal (see p. 41) the great body-artery, known as the *aorta*, starts from the left ventricle in an *aortic arch*, which curves round to the left, while in a Bird there is a similar arrangement, except that the aortic arch curves round to the right. In the Lizard there is, as it were, a combination of both conditions. There is a *right aortic arch*, resembling a Bird's in that it arises from the left half of the ventricle and curves over to the right. Since this arch starts from that side of the ventricle which receives pure blood from the left auricle, it has blood of that sort pumped into it. And since the arteries supplying the head and fore-limbs are branches of the right aortic arch, these parts of the body are necessarily supplied with pure blood. And it is natural that the brain above all organs should get a pure blood supply, which it does in this way.

But there is also a *left aortic arch*, curving as in the Mammal, and conducting away some of the impure blood from the right half of the ventricle. The *dorsal aorta* is formed by the union of right and left arches, receiving pure blood from one, and impure blood from the other, and therefore supplying what may be called *mixed* blood to the trunk, tail, hind-limbs, and most of the internal organs. Yet another point deserves attention. Each of the aortic arches is *double* for part of its extent, and really represents a pair of arches fused together. The presence of one or more arches at the beginning of the great arteries of the body in terrestrial Vertebrates strikes one as peculiar, and without reference to Fishes is inexplicable. As will later be explained, however, it is an indication of descent from gill-bearing ancestors (see p. 244), for the circulatory organs of lung-bearing forms are not

constructed on a brand-new pattern especially suited to their requirements, but are simply a modification of the more ancient arrangement found in fish-like animals. In both Mammals and Birds the modification is very perfect, and there is a complete separation of pure and impure blood; but in Reptiles and Amphibia the separation is less complete, and the relative sluggishness of these creatures is partly due to the fact that their bodies are to a large extent supplied with mixed blood, *i.e.* with blood which, being a mixture of pure and impure blood, is only imperfectly oxidized.

Not only does the Lizard possess an *hepatic portal system* (see p. 41), by which the blood of the digestive organs is carried to the liver, but there is also a *renal portal system* in connection with the kidneys, by which some of the impure blood from the hinder part of the body is supplied to those organs, the function of which is, as elsewhere, to get rid of nitrogenous waste.

Breathing Organs and Organs of Voice (fig. 131).—The arrangements connected with respiration are here much simpler than in either Mammals or Birds, which is what might be expected, as cold-blooded animals have not the same need for thorough and rapid oxygenation of the blood, though at the same time it must be remarked that Lizards exhibit less complication than is usual among Reptiles.

On the floor of the mouth behind the tongue there is a slit-like *glottis* leading into the organ of voice or *larynx* that forms the beginning of the *wind-pipe*, which runs back and forks into two bronchi, one for each lung (see p. 46). These air-tubes are supported by gristly rings, and thus prevented from collapsing. Nothing is present equivalent to the syrinx or song-box of a Bird (see p. 149). The *lungs* are spindle-shaped bags, the linings of which are raised into a honey-combing of ridges, by which the surface exposed to the air is considerably increased.

Nervous System and Sense Organs (fig. 131).—Only a few points call for special attention. As previously remarked (p. 192), the flatness of the head is an indication of the relatively small size of the *brain*. At the front end of this organ are the club-shaped *olfactory lobes*, which supply the fairly well developed organs of smell, and pass back into the smooth *cerebral hemispheres*, the relatively small size of which as compared with a Bird (see p. 149) is an index of inferior intelligence. Still farther back are two

large *optic lobes*, much like those of a Bird (see p. 150), but placed side by side on the upper side of the brain instead of being separated from one another. Lastly comes the *medulla oblongata*, which passes gradually back into the *spinal cord*, and exhibits on its upper side, just behind the optic lobes, a small smooth lobe which corresponds to the complicated *cerebellum* found in a Mammal or Bird (see pp. 52 and 150). A side view of the brain shows clearly a sharp downward bend (cranial flexure) in the region of the medulla oblongata.

The same *sense organs* are present as in a bird, though there are many differences in detail; and it may be particularly mentioned that the complex bag or membranous labyrinth (see p. 150), which is imbedded in the side wall of the skull and constitutes the inner ear, is rather less complex.

In dealing with the skull it was mentioned that there is a small hole, the parietal foramen, in the roof of the brain-case. This hole is occupied by a rounded structure, which in some Lizards has clearly the structure of an eye, so much so that it is usually called the *pineal eye*. It is connected with a sort of stalk which runs upwards from that part of the brain-axis of which the cerebral hemispheres are outgrowths. Even in Lizards this unpaired eye is more or less degenerate, and it is only represented in most of the Vertebrates by the stalk just mentioned, to which the name of "pineal body" is usually given. Even in the human brain a pineal body can be distinguished, and the fact that the philosopher Descartes regarded it as the seat of the soul has invested it with a certain curious interest. It is clearly to be regarded as one of those "vestigial organs" or "vestiges" which are of common occurrence in the animal body, and represent the dwindling remains of structures which were of importance in ancestral forms.

Development.—The Sand-Lizard lays eggs much like those of a bird, but with softer shells.

Classification of Reptiles.—Leaving the numerous extinct groups out of consideration, as these will be dealt with elsewhere, Reptiles may be divided into five orders, as follows:—

1. Crocodilia: Crocodiles, Alligators, &c.
2. Chelonia: Turtles and Tortoises.
3. Lacertilia: Lizards.
4. Ophidia: Snakes.
5. Rhynchocephala: Hatteria, a lizard-like New Zealand form.

It may be well at this point to summarize the chief features, all of which have been illustrated in the foregoing description of a Lizard, in which these five groups agree, or, in other words, to give a definition of the Reptilia.

Reptiles are cold-blooded Vertebrates defended by an exo-skeleton composed of either epidermic scales, or bony dermal scutes, or it may be of both. In those forms which possess well-developed extremities, there are always more than three digits in the fore-limb, and commonly five in the hind. *The skull is jointed on to the backbone by a single occipital condyle, each half of the lower jaw consists of several bones,* and the surfaces of the vertebral centra are not saddle-shaped. The sacrum is made up of two vertebræ. The interclavicle, when present, does not fuse with surrounding parts, and in existing forms the ilia do not extend far in front of the acetabula, both pubes and ischia unite together ventrally, and the tarsus fuses neither with the tibia nor with the metatarsus. *The ankle-joint is in the middle of the tarsus.* Conical teeth are usually present (except in Chelonia) and *the gut ends in a cloaca.* The heart possesses two auricles but (except in Crocodilia) only one ventricle, and in all cases the body is partly supplied with mixed blood. There is never less than one pair of aortic arches. The brain is small, and the optic lobes are placed close together on its upper side. *Breathing is in no case effected by means of gills.*

There are many points of agreement between Reptiles and Birds, and this is especially striking if extinct forms are taken into consideration. Those characters which are printed in *italics* in the above definition are common to both groups, which are often associated together into a larger division, the Sauropsida, contrasting with Mammals on the one hand and Ichthyopsida (Amphibia plus Fishes) on the other.

Order 1.—Crocodiles (Crocodilia)

Crocodiles and Alligators (fig. 133) much resemble gigantic lizards in appearance, and agree with these in many particulars of structure, though decidedly of higher type. As is well known, these animals spend a large part of their time in water, and some of their peculiarities of structure are related to the aquatic habit. The large and hideous head provided with formidable

jaws is separated by an ill-marked neck from a long body, and this again passes into a long and powerful tail, which is the chief swimming organ. The body is flattened from above downwards, and the tail, in correspondence with its function, from side to side. The sprawling lizard-like limbs do not lift the trunk well off the ground, the feet are webbed to some extent, and there are five digits in the fore- but only four in the hind-limb, the little toe being represented only by a small bone visible in the prepared skeleton.

Returning to the head, we find several arrangements that are of special use to an aquatic form. The slit-like nostrils are situated on the tip of the snout, and can be closed by muscular action so as to prevent entry of water when the animal is submerged, while their position enables breathing to go on when only a very small part of the body is above the surface. As in birds and lizards (as well as some mammals), the eye possesses not only upper and lower eyelids but also a third eyelid which can be drawn over it for protection, and the tympanic membrane, corresponding in position to that of the lizard (see p. 192), is provided with a little protective flap or "ear-lid" which can be folded over it.

The chief peculiarity of the *skin* (fig. 133) is found in the fact that it develops a very complete exoskeleton, composed externally of rectangular horny scales, which on the tail and upper and lower sides of the trunk are disposed in regular longitudinal and transverse rows. Some of these scales project upwards from the upper side of the tail, forming a jagged crest. This, however, is not all. Underlying the scales of the upper and sometimes of the under surface are sculptured bony plates (scutes), which are developed in the deeper part of the skin (dermis). The arrangement of the scales and scutes differs in different species, and affords characters which are of use in classification. The strong musky odour which distinguishes crocodiles is due to the secretion of musk-glands, some of which open on the edge of the upper jaw, others into the cloaca, and the remainder on the dorsal surface of the trunk.

The *endoskeleton* of the crocodile can be compared point for point with that of the lizard, though it presents a number of interesting peculiarities. In the large and massive *skull* the boundaries between the separate bones can be always

made out, and the upper surface is sculptured something like the scutes. It is, indeed, almost certain that some of the flat bones which help to cover in the skull in those vertebrates possessing a bony skeleton are in reality scutes which have sunk inwards and attached themselves firmly to underlying parts.

The bones of the jaw are very long, and their margins present a large number of sockets, arranged in a single row, for the reception of the formidable pointed teeth. As in a bird or lizard, the lower jaw hinges on behind to an elongated bone known as the quadrate (see p. 143); but whereas in those forms the bone in question is more or less movable so that a sort of double jaw-joint is constituted, here it is firmly fixed to the skull. Such a double joint detracts somewhat from firmness, which is very necessary to an animal that, like a crocodile, has to overcome prey possessing considerable muscular strength. And further, the long jaws enable the mouth to be opened widely enough without the presence of a joint of the kind. A notable peculiarity is found in the very great length of the bony palate which supports the roof of the mouth, and above which runs a passage into which the cavities of the nose open, and along which air is conducted to and from the glottis, or aperture of the windpipe. In a bird or lizard the internal openings of the nasal cavities are situated on the roof of the mouth fairly far forwards, but in the crocodile the arrangement described throws them very far back, and as the top of the windpipe projects into them a distinct air-passage from the external nostrils backwards is constituted, so that breathing can take place when the tip of the snout is above water, even if the mouth be open, without any danger of water getting down into the lungs. Similar anti-choking arrangements are found in other air-breathing aquatic vertebrates, and will be described in another chapter.

The thoracic *ribs* exhibit one feature which is characteristic of birds, each of them having a backwardly-directed plate on its margin not very far from the backbone (see p. 145). These uncinate processes add to the firmness of the wall of the chest. Not only are ordinary ribs present, but also "abdominal ribs", situated behind the sternum and developed in connection with the muscles. It is interesting to note that ribs of the kind are also present in the oldest known fossil bird (*Archæopteryx*),

which also approached reptiles in other more important particulars, such as the possession of teeth and a long jointed tail.

In the skeleton of the *limbs* the absence of clavicles may be noted (see p. 145), and also the fact that both tarsus and carpus are considerably modified. One of the bones of the former (calcaneum) has a heel-like projection, and this is the only case outside the Mammalia where anything of the kind is present.

The *digestive organs* (fig. 132) are interesting in a number of ways. The strong conical teeth which form an irregular row along the margin of each jaw are, as already mentioned, imbedded in distinct sockets, and, as in lizards, are replaced to an indefinite extent by successors which grow up from below and push them out as they get worn down with wear. When the jaws are

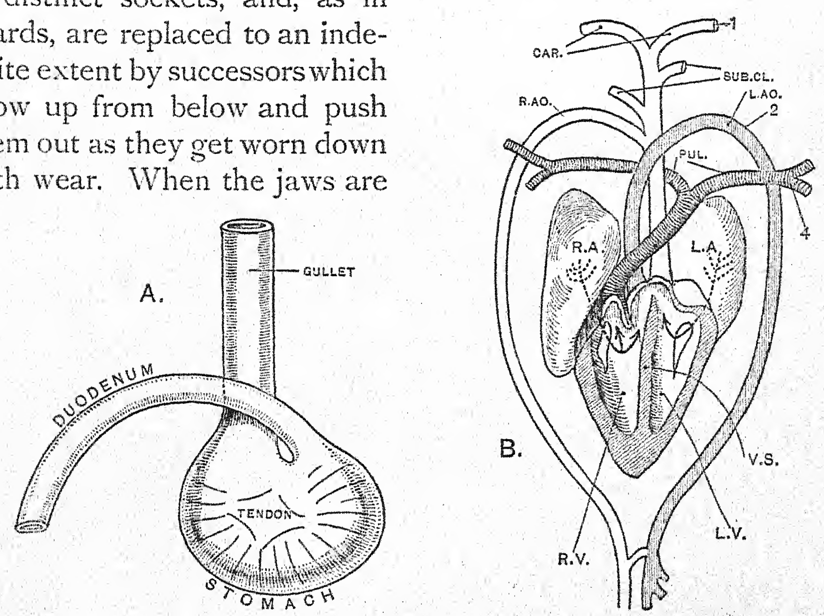


Fig. 132.—Structure of Crocodile

A, Stomach and related parts. B, Diagram of Heart and great blood-vessels: R.A. and L.A. right and left auricles; R.V. and L.V. right and left ventricles cut open; V.S. ventricular septum; 1, 2, 4, aortic arches of left side; R.AO. Right aorta; L.AO. Left aorta; SUB.CL. subclavian arteries; CAR. carotid arteries; PUL. Pulmonary arteries. Arrows show course of blood.

brought together the upper and lower teeth interlock, forming a very efficient arrangement for seizing and holding. There are no teeth on the roof of the mouth as in a lizard (see p. 199), and the tongue is a flat rounded organ devoid of any great mobility. Crocodiles are in the habit of pulling their prey under water and holding it there till drowned, during which operation a good deal of water must get into the mouth of the aggressor. In the way already explained this water is prevented from

getting down into the lungs, and there are soft projections at the back of the mouth-cavity which can be brought together so as to keep it out of the gullet. In other words, the hinder part of the mouth-cavity is partitioned into a *pharynx* (see p. 34), which passes back into the wide *gullet*. This in its turn communicates with a *stomach* which is singularly bird-like, since part of it is modified into a muscular gizzard (see p. 146). The resemblance is strengthened by the crocodile's habit of swallowing stones, which presumably help, as in a bird, to grind up the food. This is the more necessary since the teeth are not suited for chewing, and the prey is either swallowed whole or in large pieces, according to its size. As in Birds and Lizards (see pp. 146 and 200) the *large intestine* terminates in a *cloaca*, which opens to the exterior by a longitudinally oval aperture situated on the under side of the root of the tail.

The *blood*, *heart*, and *blood-vessels* (fig. 132) are much like the corresponding parts in the lizard (see p. 200), the most important difference being that there are two ventricles, a feature possessed by no other known reptile. This limits the impure blood to the right side of the heart and the pure blood to the left, as in mammals and birds, but the advantage gained is less than at first sight appears, for the two kinds of blood mix *outside* the heart. This is so because we still have, as in the Lizard (see p. 201), two aortic arches, a right which takes origin in the left ventricle and carries off pure blood from it, and a left which conducts away impure blood from the right ventricle. It is clear, therefore, that the dorsal aorta, which is formed by the union of the two arches and which supplies the body behind the fore-limbs, must contain mixed blood, and the two arches also communicate by a small hole just where they leave the heart. A reduction of the aortic arches has taken place as compared with the Sand Lizard (see p. 191), for each of them is here single instead of being formed by the partial union of two. If the left arch were entirely done away with we should have a condition closely resembling that found in the bird (see fig. 102), and all parts of the body would be supplied by pure blood. There can be little doubt that some of the remote reptile-like ancestors of birds possessed circulatory organs much like those of the crocodile, and that in them part of the body was consequently supplied with mixed blood.

The *breathing organs* and parts connected with them differ from those of the lizard not only in the arrangement of the air-passages as already described, but also in the structure of the lungs themselves, which have relatively thick spongy walls. A similar arrangement, however, is found in some large lizards, and, speaking generally, it is only small reptiles which have very simple lungs. Crocodiles also possess an imperfectly-developed representative of the muscular partition known as midriff or diaphragm, which plays such an important part in the breathing movements of Mammals (see p. 46).

The *brain* of a crocodile is of higher type than a lizard's, both cerebral hemispheres and cerebellum being much larger in proportion. The *sense organs* are also more complex, especially those connected with smell and hearing. In the latter case it is interesting to note that the complex bag known as the membranous labyrinth (fig. 103), which constitutes the essential part of the inner ear, is shaped very much as in a bird, there being a well-developed curved tube to represent the coiled cochlea of Mammals.

Crocodiles are hatched out from eggs much resembling those of birds, and laid in holes or imperfect nests scooped out in the sand, where they get the benefit of the sun's heat. The young reptile has a horny wart on the tip of its snout, which helps it to break through the firm egg-shell.

The existing members of the order Crocodilia (fig. 133) are found in tropical and sub-tropical regions both in the New and Old Worlds. Three groups are commonly recognized:—(1) Alligators; (2) Crocodiles proper; and (3) Garials.

Alligators, with the exception of a Chinese species, are confined to the tropical parts of America. The snout is relatively short and broad, and the different teeth are of very unequal size, among the large ones being the first and fourth in the lower jaw, which bite into pits in the upper jaw in such a way that they are hidden from view when the mouth is shut. There are several special features in the skull, of which perhaps the most striking is the shortness of the region where the two halves of the lower jaw unite together in front. Some members of the Alligator group possess scutes on the under side of the body as well as on the upper. The hind-limbs have a rounded outline and the toes are only half-webbed.

Three species are known of the Alligator proper, one being found in China, and the others in the south-east part of North America, of which two by far the best known is the Pike-headed or Mississippi Alligator (*Alligator Mississippiensis*), which may attain the length of about 15 feet. The first name given to this creature expresses a resemblance to the fresh-water fish well known as the Pike.

The remaining members of the Alligator group, the *Caimans* or *Jacares*, are limited to Central America and the tropical parts of South America. The different species vary greatly in size; all but one, however, being much smaller than the Mississippi Alligator. Unlike the Alligators proper the Caimans possess ventral scutes, and those which make up the dorsal armour are firmly united with one another.

Crocodiles proper have a very wide distribution throughout the tropics, being found in America, Africa, South Asia, and North Australia. The head is somewhat narrower and longer than in alligators, and the teeth are not so markedly unequal. Although, as before, the large first lower tooth bites into a pit, this is not the case with the large fourth lower tooth, which merely bites into a groove and is partly visible when the mouth is shut. The united part of the lower jaw is rather longer than in alligators, as might be expected from the shape of the head, and there is no ventral bony armour as in caimans. The hind-limbs have a jagged posterior fringe, and the feet are more completely webbed than in alligators.

Probably the most familiar species is the Nile Crocodile (*Crocodilus Niloticus*), which was regarded as sacred by the ancient Egyptians, and like other animals which figured in their religion was considered worthy of embalmment. It has now been exterminated in the lower Nile, where it was formerly very abundant, and its range includes South Africa, Senegal, Madagascar, and Syria. Large specimens may considerably exceed the Mississippi Alligator in size.

The Indian Crocodile (*Crocodilus palustris*) ranges from Baluchistan to the Malay region, and avoids the tidal parts of rivers. Another Indian species, the Estuarine Crocodile (*C. porosus*), has exactly the contrary habit, as the name indicates, and is not only common in estuaries, but swims out to sea for a considerable distance. This fact is interesting, for the vast

Fig. 133.—Crocodilia

1. Chinese Alligator (*Alligator Sinensis*). 2. Spectacled Caiman (*Caiman sclerops*). 3. Nile Crocodile (*Crocodilus Niloticus*). 4. Ganges Garial (*Garialis Gangetica*).

majority of existing reptiles are confined to land or fresh water, though some of the extinct groups were exclusively marine. The Estuarine Crocodile is one of the fiercest and most dreaded species, and at the same time probably the largest, for a specimen has been recorded as having the great length of 33 feet. It ranges from the east of India to South China, North Australia, and the Solomon and Fiji Islands.

American Crocodiles have slender snouts, a feature possessed in an exaggerated form by a West African Crocodile (*C. cataphractus*).

Garials form a small group of crocodilian reptiles, distinguished by extremely slender snouts, and jaws armed with a large number of comparatively small teeth, all fairly equal in size and arranged with greater regularity than in the other forms. These special modifications convert the jaws into a very perfect fish-catching arrangement, which is paralleled in some of the aquatic Mammals (Cetacea). The first and fourth lower teeth bite into grooves above, and, as is but natural, the united part of the lower jaw is extremely long. The feet are more completely webbed than in other crocodilians, and both fore- and hind-limbs have a posterior ragged fringe. There are only two existing genera, both confined to the south of Asia.

Schlegel's Garial (*Rhynchosuchus Schlegeli*) is found in Borneo, and may attain the length of 14 feet. The better-known Gangetic Garial (*Garialis Gangetica*) is confined to the Ganges, Indus, Brahmaputra, and some smaller Indian rivers. It is of larger size than the Bornean Garial (20 feet), and the snout is longer and more slender. By the natives they are regarded as sacred.

Order 2.—Toothless Reptiles (Chelonia)

This order includes the Turtles and Tortoises, toothless Reptiles provided with a remarkable defensive exoskeleton.

The most familiar member of the group is the small Grecian Tortoise (*Testudo Græca*), common as a pet in this country, and indigenous to the south of Europe (fig. 134). The short broad trunk is enclosed in a strongly arched shell, forming a sort of box with an opening in front into which the head, neck, and fore-limbs can be withdrawn, and a similar opening behind for the benefit of the hind-limbs and stumpy tail. The head is

rounded, and the toothless jaws, covered as in birds with firm horny sheaths, give it a very characteristic appearance. Two small rounded nostrils are seen close together on the front of the head, the fairly large eyes are provided, as in lizards, with three eyelids, and behind each of them is a depression in which the tympanic membrane is visible. Protection is afforded by a number of horny plates united by their edges. The immobility of the trunk is largely made up for by a fairly long and exceedingly

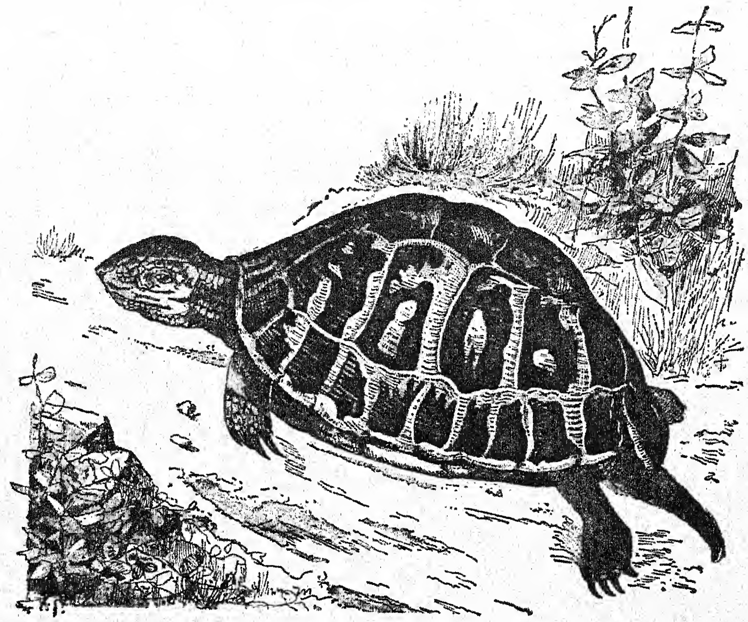


Fig. 134.—Grecian Tortoise (*Testudo Græca*)

flexible neck, covered by soft skin. When retracted it is thrown into an S-shaped curve. The stumpy limbs are adapted for terrestrial locomotion, and can lift the body well off the ground. As, however, the movements are extremely slow, defensive armour is a necessity, and on the slightest alarm the animal withdraws head, neck, tail, and limbs into the cover of the shell, when the protective arrangements are completed by the horny plates on the head and strong overlapping scales which are present on the limbs.

The usual limb-regions are present, though not well marked externally, and the existence of five digits in either extremity is indicated by a corresponding number of blunt claws.

The *exoskeleton* resembles that of caimans, in that there are

not only horny plates and scales of epidermal nature, but also bony pieces developed in the deeper part of the skin both above and below. Here, however, these pieces cannot be stripped off with the skin, but are to a great extent intimately welded to parts of the internal skeleton. The arched upper or dorsal half of the shell is termed the *carapace*, and the flat under or ventral piece with which it is firmly united at the edges is the *plastron*. It will be convenient first to deal with the superficial horny shields and then with the underlying bony plates. Beginning with the carapace, there is a series of *neural shields* running down the centre, and these are flanked on either side by broad transverse *costals*, outside which again are more numerous *marginals*, forming a right and left series separated in the extreme front by a median *neck-shield* (nuchal) and behind by a pair of *caudals*. Some of the marginals on either side bend sharply round to the under surface and help to cover the bones of the plastron. The greater part of this, however, is veneered by six pairs of horny shields, of which those in front (gulars) and behind (anals) are smaller than the rest, which have received the names of humerals, pectorals, abdominals, and femorals.

When these horny shields are stripped off, a number of bony plates are exposed which have a very similar arrangement, though their number is not the same, and therefore, of course, their edges do not correspond with those of the overlying plates, as is the case with the armour of caimans. Running down the middle of the carapace are eight *neural plates*, which may be regarded as the flattened tops of vertebræ, and which are continuous on each side with a similar number of *costal plates* fused with the underlying ribs. The carapace is completed by a *nuchal plate* in the middle of its front margin and *pygal plates* similarly placed behind, while a series of eleven *marginal plates* are disposed on either side. The plastron is made up of one unpaired plate, and four others arranged in pairs. The former is possibly to be compared with the interclavicle of a lizard (see p. 198), while the others are in all probability to be regarded as equivalent to the abdominal ribs of the crocodile.

As will have been gathered from the foregoing description, there is intimate union between bony plates belonging to the external skeleton and parts of the *internal skeleton*, *i.e.* the

ribs and trunk vertebræ, and we see here that the girdles of the limbs are brought within the shelter of the ribs, a remarkable and unique arrangement. The immobility of the trunk is largely made up for by the great flexibility of the neck, which is supported by eight vertebræ, of which the centra exhibit great variety in the shape of their ends. There is no breast-bone, the presence of the plastron rendering it quite unnecessary.

As regards the *skull*, it need only be noted here that the jaws possess a continuous sharp bony edge for the support of the horny sheaths which do duty as teeth. The lower jaw is jointed on to a massive quadrate bone which, as in a crocodile, is firmly fused with the rest of the skull.

The skeleton of the *fore-limb* corresponds pretty closely to the theoretical type, except that some of the bones have fused, as radiale with centrale, and carpale four with carpale five. In the *hind-limb* there is a fair correspondence with the type, but, as in Reptiles generally, there is a good deal of fusion in the ankle-bones and a tendency for the ankle-joint to come between the two rows of these.

The *food* of the Grecian Tortoise consists mainly of vegetable matter, but it also devours sundry small animals, such as worms, insects, and snails. The *digestive organs* present no points of very special interest, but it may be noted that the tongue is comparatively immobile, as in the crocodile, and, as in that animal, the large intestine ends in a cloaca which opens externally by a longitudinal slit.

Except as regards its flattened shape, the *heart* of a tortoise closely resembles that of the Sand Lizard (p. 191), and there is also agreement in reference to the great blood-vessels which enter and leave it, each of the two aortic arches, however, as in crocodiles and the larger lizards, being single instead of double for a part of its course. The body is therefore, as in other Reptiles, largely nourished by imperfectly-purified blood, and a tortoise is a particularly good example of the sluggishness and cold-blooded condition entailed by this arrangement. It also exhibits in a very marked way the great tenacity of life which distinguishes cold-blooded vertebrates when compared with birds and mammals.

The *breathing-organs* agree in most respects with those of

the crocodile, but the internal nostrils open on the roof of the mouth, as the habits of the animal do not require any special provision to be made for a distinct breathing tract as distinct from the cavity of the mouth. It may also be remarked that the immobility of the trunk presents a certain obstacle to the rapid renewal of the air in the lungs, and this is probably the chief reason for the sluggishness of chelonians.

The *brain* presents the usual parts, and is, for a reptile, of comparatively high type, being only inferior to that of the crocodile.

Tortoises are developed from hard-shelled eggs much like those of a bird. About a dozen of these are deposited together in a hole scooped out in the earth, and are afterwards carefully covered up. A warm spot is selected for the purpose, and the eggs, which are laid in early summer, are hatched out by the heat of the sun.

The following groups are recognized among the Chelonia, and in dealing with them space will only permit of allusion to some of the more interesting forms:—

(1) Leathery Turtles.
(2) S-necked Chelonia.
    (*a*) Land and Fresh-water Tortoises.
    (*b*) Turtles.
(3) Side-necked Tortoises.
(4) Soft Tortoises.

(1) *Leathery Turtles.* — This group contains but a single species, the Leathery Turtle or Luth (*Sphargis* or *Dermatochelys coriacea*) (fig. 135), which differs in many important particulars from other Chelonia, not only from the terrestrial and fresh-water forms, but also from the Turtles proper, which, like it, are marine. It is the only living representative of an important extinct group, some members of which attained a very considerable size, and is the largest existing marine species, being when full-grown over 6 feet long. The limbs are modified into large nailless flippers, which are very efficient swimming organs. These, however, are not its special peculiarity, for similarly modified limbs are found in ordinary turtles, but this is found in the nature of the "shell". The carapace is made up of numerous bony pieces united together in a tesselated manner and quite free from the

underlying ribs and vertebræ, besides which there is a complete absence of overlying horny plates, the place of these being taken by leathery skin raised into a small number of prominent longitudinal ridges. The plastron is not so well developed as in

Fig. 135.—Leathery Turtle (*Dermatochelys coriacea*)

ordinary turtles, and is covered by ridged skin resembling that on the upper surface. These creatures are found in the tropical parts of all the great oceans.

(2) The *S-necked Chelonia* include the large majority of existing species, and are so called because the head, when retracted, is drawn straight back into the shell, being at the time thrown into an S-shaped curve.

(*a*) *Land and Fresh-water Tortoises.*—The genus *Testudo* (figs. 134 and 136), to which the Grecian Tortoise (*Testudo Græca*) belongs, is a representative of the largest family of Land Tortoises, or indeed of Chelonia generally, including a score of genera which embrace between them some 113 species. The family is found in all parts of the world except Australia, New Guinea, and the related islands. Among the most interesting

forms included in the same genus with the Grecian Tortoise are fourteen giant species, which either are or have been within the last 300 years inhabitants of some of the islands in the Indian and South Pacific Oceans. Of these probably the best known are those found in the Galapagos Islands off the north-east coast of South America. Several species have been described, one of which (*Testudo nigrita*) was described by Darwin as reaching such large dimensions that large specimens could only be lifted by from six to eight men.

The European Pond-Tortoise (*Emys orbicularis*) may be mentioned as a good example of a fresh-water form. In accordance with its aquatic habits, the shell is much flatter than in a land tortoise, and the feet are webbed. It is a native of South Europe, South-west Asia, and parts of North Africa. Specimens, mostly of small size, are often exhibited for sale in this country.

(*b*) *Turtles* are marine Chelonia obviously adapted for aquatic life, as may be seen from their flattened shells and paddle-like limbs, the digits of which have for the most part lost their claws. The front end of the carapace is notched, and the head can be only partly retracted. The true turtles somewhat resemble the Leathery Turtles (see p. 217) in form, a result of adaptation to the same sort of life, but, unlike the latter, the shell is covered by horny plates, and some of the digits have retained their claws. There are also important differences as regards the plastron and carapace. The former, though not so complete as in the Grecian Tortoise, is more so than in the Leathery Turtle, while the carapace is made up of the same elements as in the tortoise and is firmly connected with the internal skeleton. Two species may be noted here—the Green Turtle and the Hawk's-bill Turtle.

The Green Turtle (*Chelone midas*), found in all the warmer parts of the ocean, is the species which has attained a doubtful sort of fame in connection with aldermanic feasts. Its short beak devoid of a hook is well adapted for biting off the pieces of sea-weed which constitute the food. The horny plates which cover the carapace are united by their edges.

The Hawk's-bill Turtle (*Chelone imbricata*) has the same wide distribution as the preceding species, but is somewhat smaller. Its strongly-hooked beak accords with a carnivorous

habit, and the overlapping horny plates covering the carapace are the source of "tortoise-shell".

(3) The *Side-necked Tortoises* are a rather remarkable assemblage of fresh-water form, owing their name to the fact that

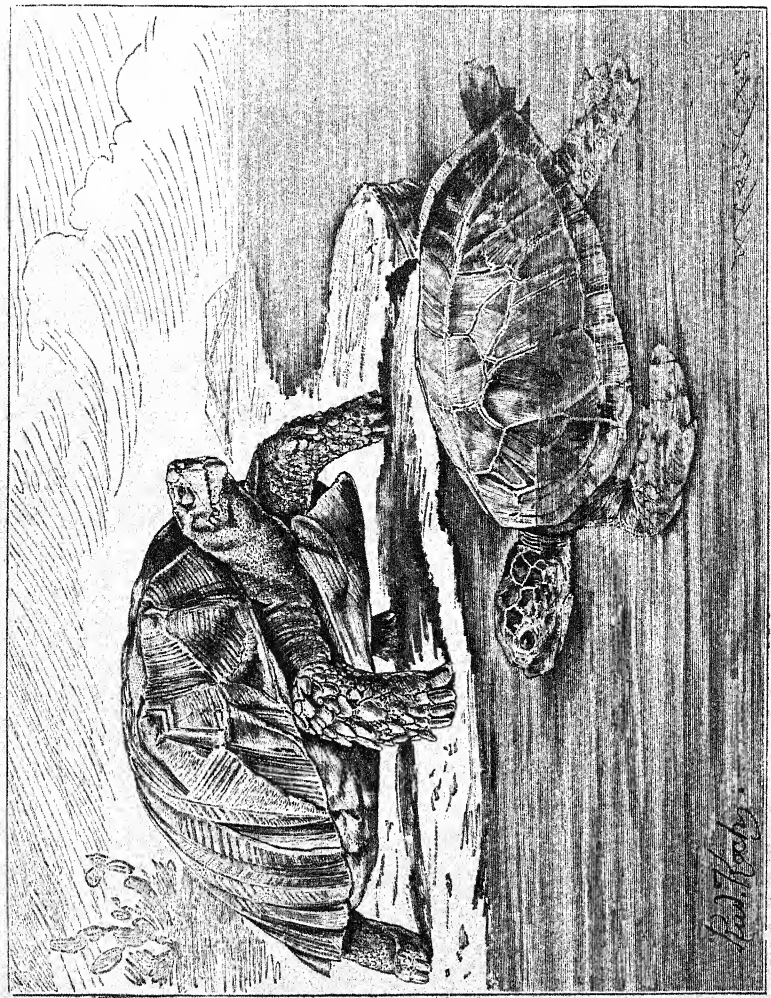


Fig. 136.—Tortoise (*Testudo sulcata*) and Green Turtle (*Chelone midas*)

the head and neck cannot be drawn straight back into the hollow of the shell, but the same end is effected by bending back the head sideways. These tortoises are all restricted to the southern land-masses, and range right round the globe, being represented in South America, Africa, Madagascar, Australia, and New Guinea.

(4) *Soft Tortoises.*—These are found in the rivers of the

hotter parts of Asia, Africa, and North America, their name being derived from the fact that the shell is entirely devoid of any horny plates. Not only so, but the carapace is deficient as regards bony elements, the marginals being either absent or largely so, and it is not united to the plastron, which is still more deficient. The shape of the body and limbs accords with the thoroughly aquatic habit, but the latter are not so completely

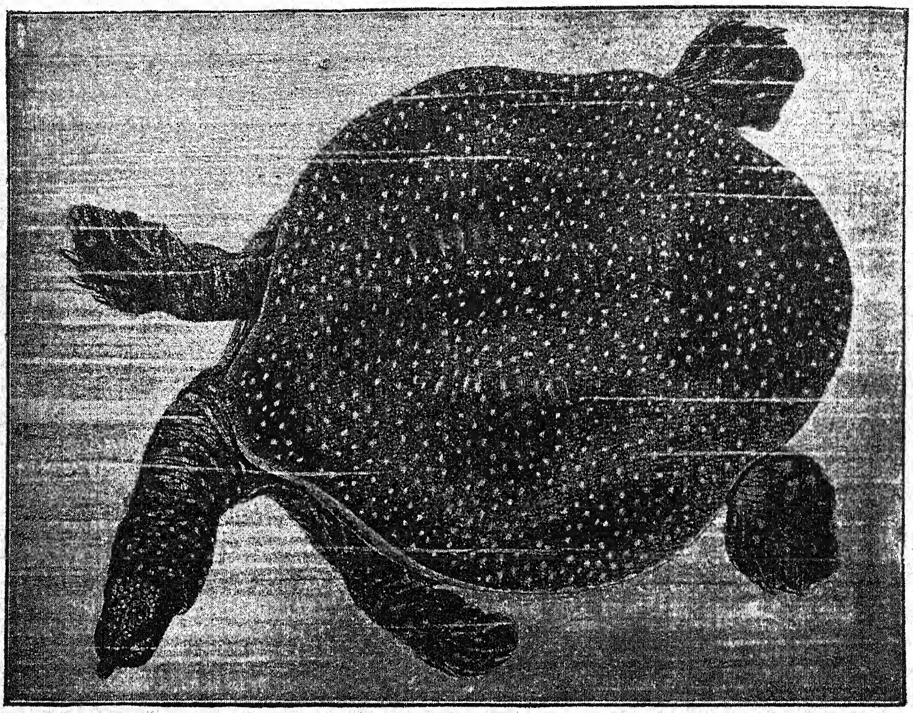


Fig. 137.—Nilotic Soft Tortoise (*Trionyx triunguis*)

converted into flippers as in the turtles. The head is provided with a curious tapering snout, and is situated upon a very long mobile neck, which on the one hand can be retracted as in the S-necked forms, and on the other can be shot out with extreme rapidity. This is, no doubt, a useful acquisition to the large carnivorous members of the group, but is at the same time a very unpleasant one, for these large species are very fierce, and the natives are often badly bitten by them. The skin is of a greenish colour as a rule, with yellow spots.

Of the six genera included among the Soft Tortoises, *Trionyx* is by far the most important and also the most widely distributed,

being the only one which extends into the New World as well as the Old. Typical species are the Gangetic Soft Tortoise (*Trionyx Gangeticus*), the Nilotic Soft Tortoise (*T. triunguis*) (fig. 137), which feeds largely on the eggs and young of the crocodile, and the common American Soft Tortoise (*T. ferox*), a native of the North American streams which flow into the Gulf of Mexico, and noted as a destroyer of the alligator's eggs and young.

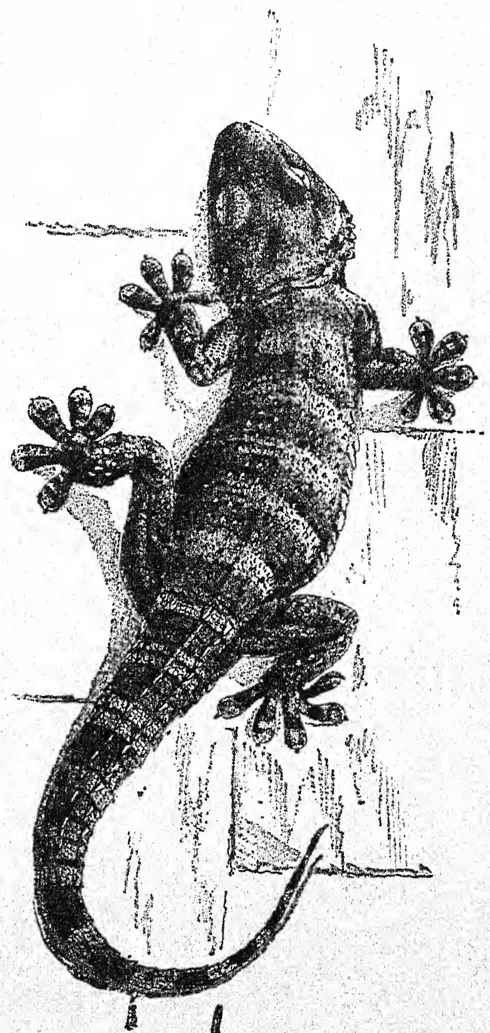


Fig. 138.—Wall Gecko (*Tarentola Mauritanica*)

Order 3.—Lizards (Lacertilia)

The large Lizard order, of which a fair average sample has already been described at some length, embraces representatives in all parts of the globe except the polar regions, and includes no less than twenty families, containing about 1700 species. It will only be possible here to mention a few of the more interesting forms, included in the families of—1. Geckos; 2. Scale-footed Lizards; 3. Agamoids; 4. Iguanas; 5. Snake-Lizards; 6. Venomous Lizards; 7. Monitors; 8. Common Lizards; 9. Skinks; and 10. Chameleons.

1. *Geckos* are small nocturnal lizards, with large eyes, and lobed feet adapted for climbing. They are found in all the warmer parts of the earth, and the Wall Gecko (*Tarentola Mauritanica*) (fig. 138) of the Mediterranean shores is the most familiar example. One structural feature of the family deserves notice here, *i.e.* the shape of the centra of the vertebræ. These are biconcave, a very primitive feature specially

characteristic of fish and low types of other vertebrate groups. In Reptiles generally it is most commonly the case that the centra are concave in front but convex behind.

2. *Scale-footed Lizards* make up a small family of snake-like forms found in Australia, Tasmania, and New Guinea. The fore-limbs are entirely wanting, though the hind-limbs are represented by lobe-like projections, but for which these creatures might well be mistaken for serpents. An examination of their structure, however, clearly shows that they are true lizards.

The Common Scale-foot (*Pygopus lepidopus*) of Australia and Tasmania may be mentioned as an example.

3. The family of *Agamoid Lizards* is a very large one, limited to the southern and eastern parts of the Old World. A typical form is the Black-lipped Tree-Lizard (*Calotes nigrilabris*) of Ceylon. Its body is of a metallic green tint, except the lips and sides of the head, which are black. Among the more remarkable members of the family are the so-called *Flying Lizards* or *Dragons* of South Asia, small forms which certainly do not live up to the latter name. These animals do not fly in the proper sense of the word, but there is a parachute-like expansion on each side of the body, supported by extensions of some of the ribs, and capable of being folded up or extended. The Malayan species (*Draco volans*) is well known. The *Thorny-tailed Lizards* of Africa and Asia have the tail covered with rings of spiny scales, and one species, the Dabb (*Uromastix spinipes*), is common in Arabia, Egypt, and Crete. Australia furnishes two remarkable species in the Frilled Lizard (*Chlamydosaurus Kingi*), which has the habit of walking about on its hind-legs, and the Moloch (*Moloch horridus*), covered with large thorny spines.

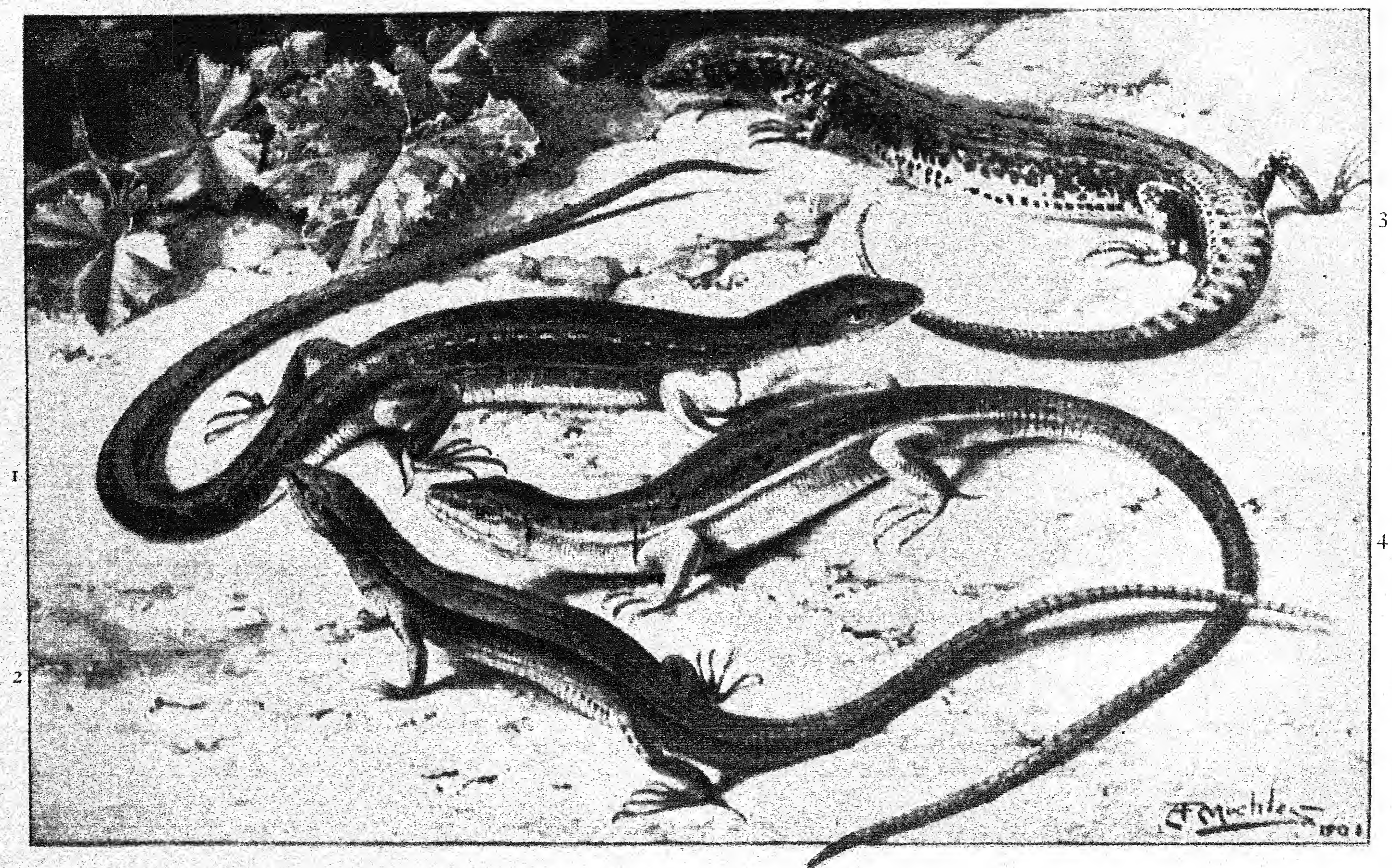
4. The *Iguanas* are, with few exceptions, found in the warmer parts of America and the West Indies. The Common Iguana (*Iguana tuberculata*) is a good type of the family, and the prominent toothed ridge running down the middle of the back is a characteristic feature. It is a vegetarian and lives mostly in trees, but is also a very active swimmer. It may attain a length of over 4 feet, which includes, however, the exceedingly long tail. One of the most interesting members of the family is the Galapagos Sea-Lizard (*Amblyrhynchus cristatus*), the only known marine member of its order. In size it rather exceeds the

TYPICAL LIZARDS (*Lacertidæ*)

The members of this family of Lizards are the most typical existing Reptiles as regards structure and habits. Their food consists of insects, worms, and other small creatures, and their hues so harmonize with the surroundings as to render them inconspicuous. This serves a double purpose, making it less easy for their enemies to see them, and also helping them to stealthily approach, without being observed, the creatures on which they feed. In scientific language they may be said to furnish examples of *general coloration* which is both *aggressive* and *protective*.

Four common European species are figured, two of which (1 and 2) are native to Britain.

1. Sand Lizard (*Lacerta agilis*).
2. Viviparous Lizard (*Zootoca vivipara*).
3. Wall Lizard (*Lacerta muralis*).
4. Green Lizard (*L. viridis*).



TYPICAL LIZARDS (LACERTIDAE)

1. Sand Lizard. 2. Viviparous Lizard. 3. Wall Lizard. 4. Green Lizard.

Common Iguana, which it resembles in the presence of a dorsal-toothed ridge. The head, however, is smaller and rounder, and there is a group of conical scales on the upper surface, while the powerful tail is flattened from side to side and thus rendered an efficient swimming organ, there being also an indication of webbing between the digits. The food consists of sea-weeds. Among the most bizarre species related to the Iguanas are the Helmeted Basilisk (*Basiliscus Americanus*) of Central America and Costa Rica, which perhaps suggested one of the fabulous animals of mediæval zoologists, the somewhat similar Capuchin Lizard (*Corythophanes cristatus*) of Costa Rica, and the Californian Horned "Toad" (*Phrynosoma cornutum*), the general appearance of which certainly does suggest a spiny sort of toad, possessed, however, of a tail.

5. The *Snake-Lizards*, of which the name suggests the external appearance, have their head-quarters in Central America and the West Indies, but also occur north and south of this in the New World, and are represented in Europe, North Africa, and India. They not only possess horny scales but also underlying bony scutes, which on the top of the head attain a relatively large size.

The most familiar species is the Blind-Worm or Slow-Worm (*Anguis fragilis*), common in Britain, and having a wide range in Europe, occurring also in North Africa and in Asia. It is

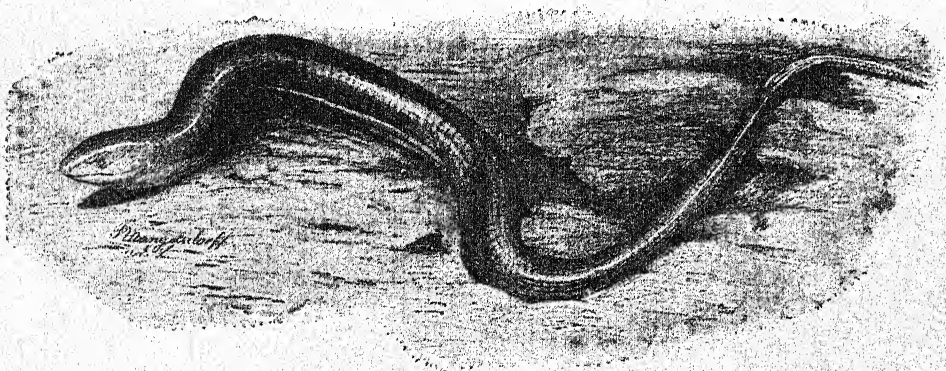


Fig. 139.—The Scheltopusik (*Ophisaurus apus*), a blind-worm native to S. Europe and S.W. Asia

often mistaken for a snake, and erroneously regarded as exceedingly poisonous. Its popular name dates back to the times when the word "worm" was applied to serpents, and a survival of this old usage appears to remain in some place-names, such as "Worms" Heath, in Surrey. The Blind-Worm exhibits no

external trace of limbs, though vestiges of these are present in some of its relatives (see fig. 139), and its teeth are slender and fang-like. Its food consists of slugs, worms, insects, and the like. The specific name "fragilis" has reference to the readiness with which the tail breaks off when the animal is handled or struck, a protective arrangement not uncommon among lizards (p. 194).

6. *Venomous Lizards* are represented only by one genus containing two species, both North American, one being from Mexico (*Heloderma horrida*) and the other from Arizona (*H. suspecta*). They are carnivorous forms of considerable size, coloured and mottled in such a way as to make them conspicuous objects when seen apart from their natural surroundings. The poison arrangement is something like that found in snakes, there being slender fang-like teeth grooved to conduct a poisonous fluid from glands at their bases.

7. *Monitors* are the largest living lizards, and are distributed over the warmer parts of the Old World. In general proportions

Fig. 140.—The Nile Monitor (*Varanus Niloticus*)

they are not unlike the typical form previously described, with which also they agree in the possession of a well-developed forked tongue capable of being thrust far out of the mouth. A common species is the Nile Monitor (*Varanus Niloticus*), which

ranges over most of Africa (fig. 140). The food consists of small vertebrates and various kinds of eggs, including those of the crocodile. The name Monitor embodies an erroneous idea that this creature hisses in a peculiar way when a crocodile approaches, and so gives a "warning" of its presence.

8. What may perhaps be called the *Common Lizards* (Lacertidæ) include some 100 species, distributed over Europe, Africa, and Asia. The Sand Lizard (*Lacerta agilis*) of Britain is one example, and the only other British member of the order (except the Blind-Worm), the Common Lizard (*Zootoca vivipara*), is another. Among the larger and handsomer forms may be noted the Green Lizard (*Lacerta viridis*), ranging from Portugal to Persia, and found abundantly as far north as Germany, and the Wall Lizard (*Lacerta muralis*), which is specially characteristic of the countries bordering the Mediterranean.

9. The *Skinks*, or *Burrowing Lizards*, constitute a family of which the distribution is world-wide. The Common Skink (*Scincus officinalis*), found on both sides of the Red Sea and on the north side of the Sahara, suggests in appearance a fish mounted on legs. The shape and smoothness of the scales are apparently features related to the burrowing habit, and the animal also possesses the useful power of seeing with its eyes shut, for the lower eyelid is provided with a transparent area which answers the purpose of a window.

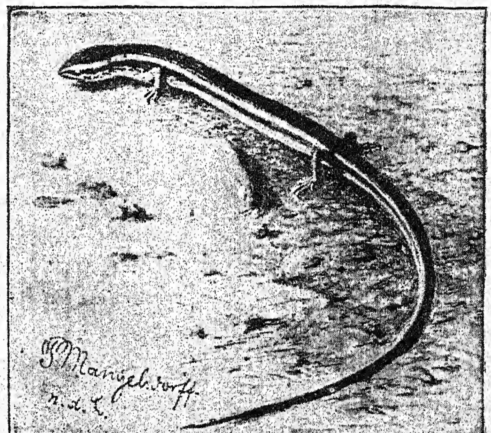


Fig. 141.—Snake-eyed Lizard (*Ablepharus pannonicus*).

The European Snake-eyed Lizard (*Ablepharus pannonicus*) (fig. 141) of South-east Europe and parts of South-west Asia is a slender creature with very small five-toed limbs.

The Three-toed Bronze Lizard (*Chalcides tridactylus*) of Italy, Sicily, Sardinia, and the opposite part of Africa, is snake-like in form, with small reduced limbs. From Roman times to the present day it has been groundlessly regarded as extremely venomous.

The most extraordinary member of the family, however, is the Stump-tailed Lizard (*Trachysaurus rugosus*) (fig. 142) of Australia, with short flattened tail, strong limbs provided with well-developed claws, and very prominent regularly-arranged scales.

10. *Chameleons* are small tree-inhabiting reptiles, familiarly known as possessing the power of changing the colour of their skins to harmonize with the surroundings for the time being.

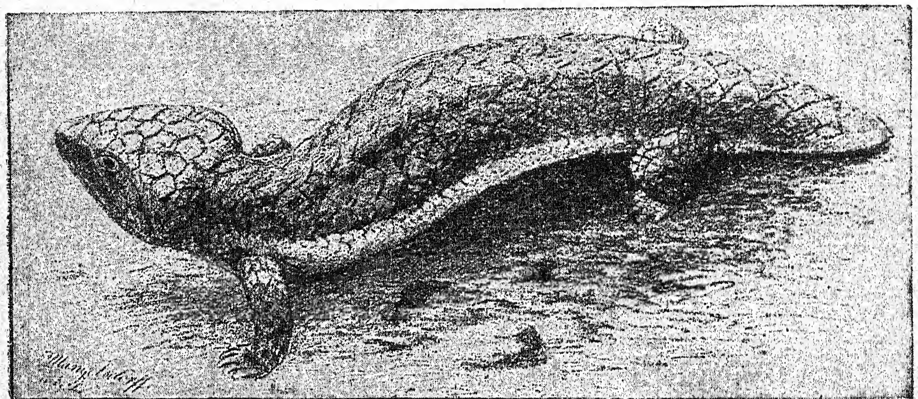


Fig 142.—Stump-tailed Lizard (*Trachysaurus rugosus*)

They exhibit many remarkable peculiarities of structure related to climbing and the capture of their prey, which consists of insects. They form a well-marked group, differing so much from the other subdivisions of lizards that it would probably be better to consider them as a distinct order. The scales are very small and granular, and the remarkable head is possessed of enormous eyes which can be moved independently of one another, while each is provided with a circular eyelid, in the middle of which is a small round hole. There is no external trace of organs of hearing. Both limbs and tail are modified for climbing. The tongue is club-ended and worm-like, and can be rapidly protuded to a distance equalling the length of the body (exclusive of the tail). Being rendered sticky by a special secretion, it forms a very efficient insect-catching apparatus. The lungs of Chameleons are of interesting structure, there being an approach to the air-sacs of Birds (see p. 148), for each lung, though fairly spongy and thick-walled in front, is produced behind into a number of thin-walled slender processes which extend between the various internal organs. It does not appear, however, that

these outgrowths are of much use in breathing, but they can be distended with air so as to swell out the body. This may be a protective arrangement.

Nearly fifty species of Chameleon are known, of which the vast majority are natives of Africa and Madagascar, though

Fig. 143.—Common Chameleon (*Chamæleo vulgaris*)

outlying members of the group are found in Arabia, India, and Ceylon, while one species, the Common Chameleon (*Chamæleo vulgaris*) (fig. 143), ranges round the eastern and southern shores of the Mediterranean, and also extends into the south of Spain.

Order 4.—SNAKES (Ophidia)

Although at first sight there seems to be a great deal of difference between snakes and lizards, careful examination shows that there are important points of resemblance, and some zoologists include the two groups in a single order, *Squamata*, among the distinctive features of which are the possession of well-marked overlapping scales, a transverse cloacal opening, quadrate bone movably attached to the skull so as to give a double jaw-joint, and simple lungs.

The elongated cylindrical form is well suited for gliding through thick undergrowth or herbage, and it may be for climbing, while some snakes are modified for swimming and others for burrowing. The resemblance to the limbless lizards is striking, but here as elsewhere too much importance must not be attached to similarity of shape, as this may result from the same or similar habits in animals which are not closely related. No snake ever possesses the least trace of fore-limbs, even their girdles being entirely absent, as also is the sternum. Snake-like lizards, on the other hand, may have very small fore-limbs or external traces of the same; and if not, as in the blind-worm, dissection shows that the girdles are represented, nor is the sternum ever absent. As regards hind-limbs, these are generally entirely absent in snakes, but vestiges are in some cases to be found one on each side of the cloacal aperture.

The head is small and flattened, passing without any perceptible neck into the trunk, and that again into a gradually-tapering tail. In nearly all cases the mouth is a wide slit, and a small rounded nostril can be seen on each side of the snout at or near its tip. The stony stare which is so characteristic of a snake is due to a very peculiar arrangement. Instead of upper and lower eyelids, there is a circular area of transparent skin by which the eye is protected, and occupying the space between this and the front of the eyeball is a tear-chamber always full of the secretion of the tear-gland.

Numerous overlapping *scales* cover the body, these being replaced on the head and under surface of the body by horny plates. *Ventral shields*, as those in the latter position are termed, are never to be seen in the limbless lizards. Snakes exhibit a great variety of colouring and marking, by which protection or other purposes are served, as will be seen elsewhere. One very characteristic habit, not peculiar to this group, however, is the periodical shedding of the outer part of the skin. The snake wriggles out of this slough, turning it inside out in the process.

The internal organs of snakes (fig. 144) exhibit a number of peculiarities, dependent partly on the elongated shape of the body, partly on the way in which prey is secured and swallowed, and partly on the manner of locomotion. The first factor, for example, influences the number of the vertebræ, and

the way in which the internal organs are packed into the long but narrow space available for the purpose.

The *skull* is made up of very hard and polished bones, its most notable features being the loose union between the various bones connected with the jaws. The two halves of the lower jaw, for instance, are not firmly united at their tip, as is the case of most reptiles, but are only connected by an elastic ligament which permits of a good deal of stretching. Not only so, but the upper jaw also is capable of a good deal of movement. This flexibility has to do with the necessity for great expansion in the act of swallowing large prey, and also plays a large part in enabling poisonous forms to use their poison-fangs effectively. It may also be noticed that the hyoid apparatus is extremely small. The long *backbone* is made up of some two or three hundred vertebræ, the centra of which have the usual reptilian shape, *i.e.* concave in front and convex behind. Such a large number of ball-and-socket joints give a very large amount of flexibility, but some provision is necessary to impose a limit to this, as otherwise dislocation would be liable to occur when complicated curvings were being described. This is partly provided for by overlapping articular processes on the arches of the vertebræ, as in most Vertebrates with well-ossified backbones (see p. 26), but in addition to these a pair of wedge-shaped projections stick out from the front of each arch and fit into corresponding pits at the back of the preceding one. It should be mentioned that similar processes are found in some other reptiles, as, for example, Iguanas, where, however, they are not so well developed.

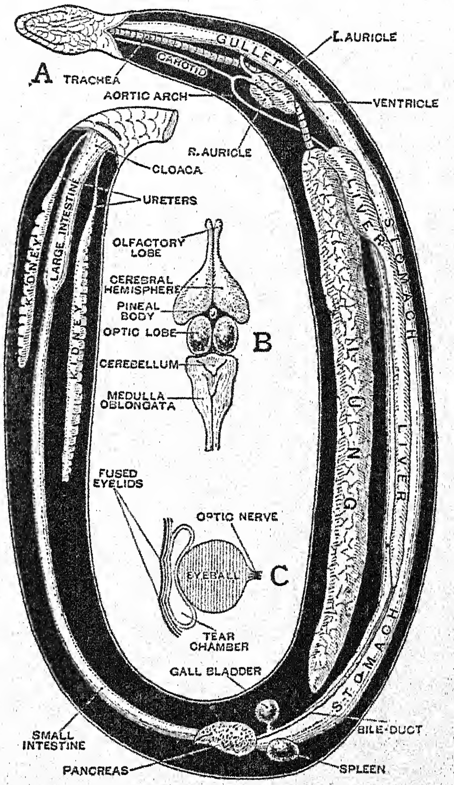


Fig. 144.—Structure of a Snake

A, General dissection. B, Upper side of brain. C, Diagrammatic vertical section to show tear-chamber in front of eye.

In the absence of both sternum and pelvis, means of distinguishing between regions of the backbone largely fail, and though the first two vertebræ are undoubtedly cervical, it is best to speak of the rest as divided into two kinds only—trunk vertebræ and tail vertebræ. Each of the former kind bears a pair of simple curved *ribs*, the free ends of which are firmly connected to a pair of the ventral epidermal shields.

The most interesting features connected with the *digestive organs* have reference to the tongue and teeth. The former is slender and forked, and can be drawn back into a kind of sheath. It is not a sting as is popularly believed, but probably serves as an organ of touch, and may perhaps also play a part in the "fascination" which a snake seems to exert over its victims. The backwardly-curved, sharply-pointed teeth are in most snakes arranged along the margins of the jaws and in two rows along the palate. In poisonous forms the two front teeth in the upper jaw are grooved or channelled for conducting poison from special glands, and it is these "poison fangs" which are capable of inflicting fatal wounds. Such a snake, therefore, is deadly in virtue of its power of giving a poisoned bite. The "sting" of a scorpion or wasp is an entirely different thing, and the organ which administers it is situated at the hinder end of the body, as most of us have practical cause to know in the case of the latter animal.

There is no occasion to dwell upon the *circulatory organs*, for in essential respects these are constructed on the plan described for the Sand Lizard (see p. 191).

The *breathing organs* are distinguished by one or two remarkable peculiarities. In the first place, the top of the windpipe is drawn out into a tube, the end of which protrudes from the mouth when prey is being swallowed, an operation that would otherwise stop the breathing altogether. The two lungs are very unequally developed, for whereas the left one is reduced to a mere vestige, the other is correspondingly large and extends far back in the body, the arrangement being convenient in a body so elongated and narrow. The hinder part of this right lung is thin-walled, and appears to chiefly serve as a reservoir of air.

The *brain* agrees in the main with the type described for the Sand Lizard, and in regard to *sense organs* one peculiarity

Fig. 145.—Pythons and Boas

1. Indian Python (*Python molurus*). 2. West African Python (*P. sebae*). 3. Anaconda (*Eunectes murinus*). 4. Boa Constrictor (*Boa constrictor*).

has already been dealt with, *i.e.* the tear-chamber of the eye. The organs of hearing consist solely of the membranous labyrinth, the sound-conducting middle ear being entirely absent. The tongue appears to be used as an organ of touch.

As at least a thousand species of snakes are known, it will only be possible here to mention a few of the more important forms. The following groups can be recognized:—1. Simple-toothed Snakes; 2. Whip-Snakes; 3. Cobras and Coral Snakes; 4. Sea-Snakes; 5. Vipers; and 6. Blind-Snakes.

1. *Simple-toothed Snakes* are non-poisonous forms, in which both upper and lower jaws are provided with rows of solid, hook-like teeth. Here are included the giant snakes known as *Pythons* and *Boas* (fig. 145), which are found in the tropical regions all round the world, but are especially abundant in South America. Among the species may be mentioned the Indian Python (*Python molurus*), which may attain a length of 30 feet, the somewhat longer West African Python (*P. sebæ*), the Anaconda (*Euneces murinus*) of tropical South America, which is credited with being the largest of living snakes, and the much smaller Boa Constrictor (*Boa constrictor*) from the same region. All these forms kill their prey by crushing, and it may also be noted that their skins are very beautifully marked with elaborate patterns. They are the only snakes which possess externally visible remains of the hind-limbs.

Not very distantly related to the giant snakes are the two harmless forms (fig. 146) which are found in Britain, *i.e.* the Grass Snake (*Tropidonotus natrix*) and the Smooth Snake (*Coronella lævis*). The former is commonly met with in the neighbourhood of fresh water, and it is a good swimmer. The frog is the favourite article of diet, but small mammals, birds, and fish are also eaten. This snake can readily be distinguished from the poisonous Adder by its colour and markings. The darker upper surface is usually brownish or greenish, marked by darker spots or narrow transverse bands, while at the back of the head is a good-sized yellow or orange patch on each side, behind these again being a broad dark "collar". The underside of the body is mottled, and of much lighter hue.

The Smooth Snake is not common in Britain, but is sometimes found in dry places in the southern English counties. It is smaller than the Grass Snake, and may readily be distinguished

by the markings on its upper side, consisting of a dark blotch on the neck and a double series of brown spots running down the body. It feeds on other reptiles.

Both these British species, especially the Grass Snake, have a wide distribution outside of Great Britain.

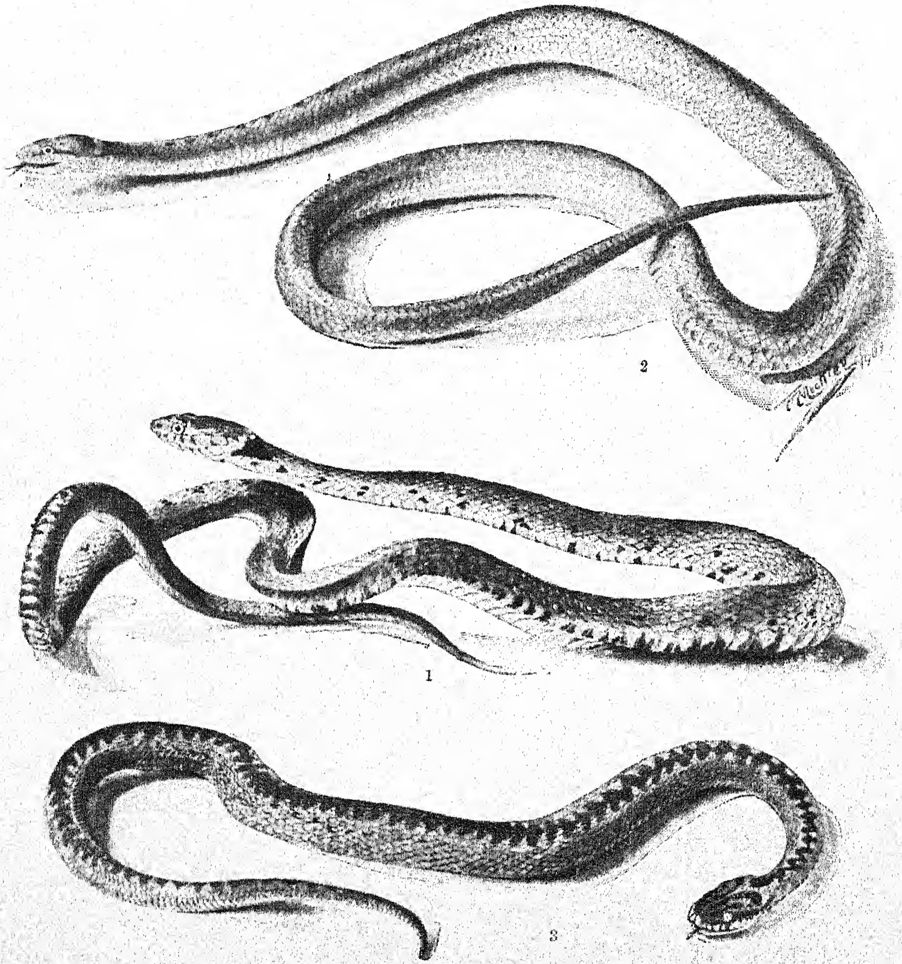


Fig. 146

1. Grass Snake (*Tropidonotus natrix*). 2. Smooth Snake (*Coronella lævis*). 3. Adder (*Pelias berus*).

2. *Whip-Snakes* and their allies are green tree-inhabiting forms, native to the tropical regions of Asia, Africa, and America. The head is small and pointed, the body extremely slender. But the most remarkable peculiarity is seen in a varying number of the hinder teeth of the upper jaw, each of which has a groove in front. Such grooves on the upper teeth of serpents generally

serve the purpose of conducting poison from a poison-gland into wounds made by the teeth, and it has been asserted that this is the case in some members of this group.

3. *Cobras* and *Coral-Snakes* are tropical forms in which the front upper teeth are grooved poison-fangs, conducting venom from poison-glands. Cobras are found in South Asia and Africa. Examples are the Common Cobra of India (*Naia tripudians*), called "cobra de capello" (hooded snake) by the Portuguese settlers on account of its power, characteristic of the genus, of inflating the skin of the neck when irritated.

The Coral-Snake (*Elaps corallinus*) of South America and the West Indies is a small form, in which the body is beautifully marked by broad scarlet rings alternating with much narrower black rings with greenish edges.

4. *Sea-Snakes* are venomous forms ranging from the Persian Gulf eastwards as far as New Guinea and North Australia. Their poison-fangs are of the same kind as described for cobras, &c., and the hinder part of the body is flattened from side to side so as to constitute a powerful swimming organ. Unlike land snakes they cast their skins in pieces, and not in a continuous slough.

5. *Vipers* of all snakes are the most specialized as regards the mechanism of the poison-fangs. Of these, two are present, and they are the only teeth in the upper jaw. The groove seen on the front of the fangs of other poisonous forms is here converted into a canal, open above to receive the fluid from the large poison-gland, and below so that this may be introduced into the wound. Hook-like teeth of the ordinary solid kind are present on the roof of the mouth and along the margin of the lower jaw. The head of a viper is flat and triangular, possessing more than in any other kind of poisonous snake the shape of the conventional "spade" on a playing-card, which is so often quoted as characteristic of venomous species. It is, however, a fallacy to suppose that all the dangerous reptiles of the order can be easily distinguished in this way.

Two species may be taken as examples, the Adder (*Pelias berus*) (fig. 146) and the Common Rattle-Snake (*Crotalus durissimus*). The former is the only poisonous British snake, and it has a very wide distribution in both Europe and Asia. Smaller than the Grass Snake, it may be distinguished from that species not

only by the shape of the head but also by the presence of a dark zigzag stripe running down the back, and it is especially common in dry localities, such as sandy heaths.

The Common Rattle-Snake (fig. 147) is a representative of the "Pit" Vipers, a group characteristic of South Asia and the New World, and so called because they possess a deep pit in front of each eye. This particular kind is a large species

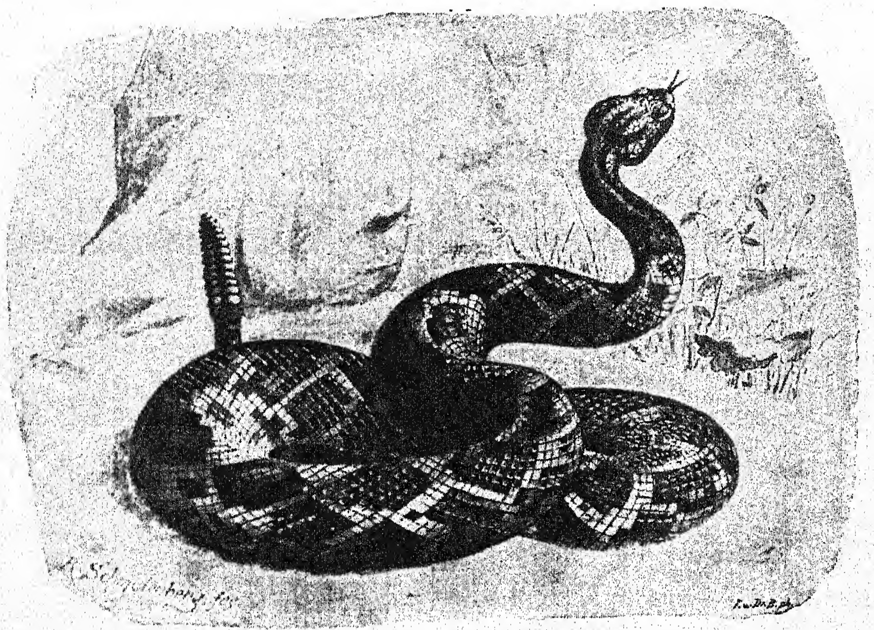


Fig. 147.—Common Rattle-Snake (*Crotalus durissimus*)

(length up to 6 feet) which inhabits North America, and, like five other allied American species, is distinguished by the peculiar organ known as a "rattle". This consists of a number of interlocked horny rings at the tip of the tail, generally supposed to be the remains of successive cast skins, though this is denied by some authorities. The rings are at any rate more numerous in old forms, while to begin with, the rattle is only represented by a button-like knob.

6. *Blind-Snakes* are small animals adapted to a burrowing life, and differing in many ways from other members of the order. The small head merges insensibly into a worm-like trunk, and that again into a very short tail. The body is uniformly covered with rounded scales, the large ventral horny

shields so characteristic of an ordinary snake being absent. The small mouth is on the under side of the head, and cannot be opened widely; nor is this necessary, as the food consists of ants and other small creatures. Strong horny plates protect the front of the head, and each of the vestigial eyes is covered by one of these.

Blind-Snakes are widely distributed through the hotter parts of both Old and New Worlds, one species, the European Blind-Snake (*Typhlops vermicularis*), ranging from Western Asia into Greece.

Order 5.—Tuataras (Rhynchocephala)

This order, which is of great age geologically, is of very special interest, because it probably comes near the ancestral stock from which all the groups of Reptiles have sprung, and

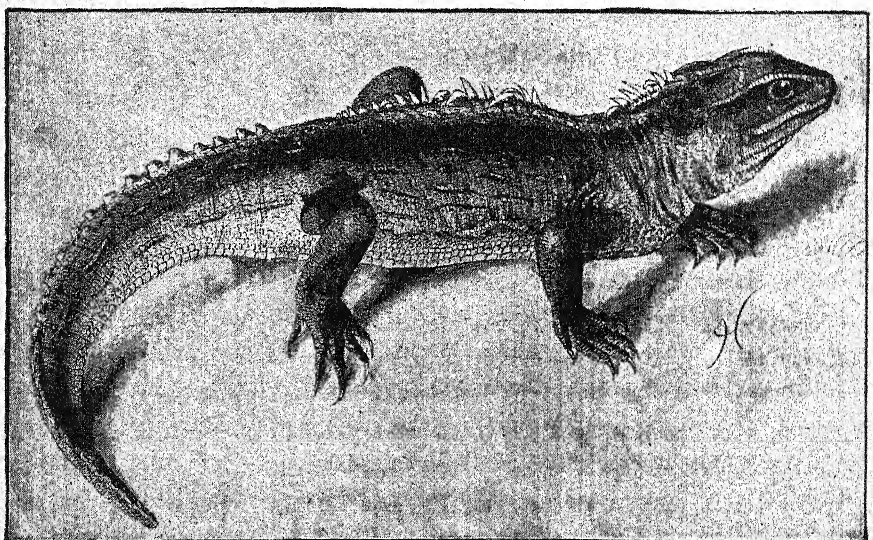


Fig. 148.—The Tuatara (*Hatteria punctata*)

also, more indirectly, the Birds and Mammals. It is represented at the present day by a solitary species, the lizard-like Tuatara (*Hatteria punctata*) (fig. 148), now unfortunately on the verge of extinction, and mainly found on, if not indeed absolutely limited to, some small islands off the north-east coast of New Zealand. In length it is about 20 inches, and, judging from external characters only, would no doubt be classified with

lizards, as was formerly the practice. The large head is fairly well marked off from the stoutish body, which again passes into a large flattened tail. The short limbs present the usual regions, and each of the extremities possesses five clawed digits. The eyes are large, but there is no external trace of organs of hearing. The scales of the upper surface are in the form of small granules, with the exception of a series of sharp spiny ones which make up a crest running down the middle line. A number of squarish horny plates arranged in transverse rows cover the under surface.

As regards its internal structure the Tuatara differs in many important points from typical lizards, but as the distinctions are largely of a technical nature, only a few of them can be mentioned here.

The *quadrate bone*, to which the lower jaw is hinged, is not movable as in a lizard (see p. 206), but firmly fixed to the skull as in the crocodile, and the two halves of the lower jaw are united together in front only by fibrous tissue. The centra of the *vertebræ* are biconcave in shape (see p. 221), and exhibit other primitive characters. The *ribs* possess uncinate processes as in Birds and Crocodiles (see p. 145), and there are *abdominal ribs* as in the latter (see p. 206). The *teeth* are also peculiarly arranged, there being two rows above, one on the upper jaw and the other on the roof of the mouth, and into the groove between these the teeth of the lower jaw bite, getting in course of time ground to a sharp edge. In the front of the upper jaw are two wedge-shaped teeth, almost reminding one of those present in a rabbit. All these teeth are firmly fused with the edges of the firm bones, and in old animals may be so much ground down that the bones themselves act as biting organs.

CHAPTER V

STRUCTURE AND CLASSIFICATION OF AMPHIBIANS

This class of cold-blooded vertebrates is often confounded with Reptiles, from which, however, its members differ in many important respects, being altogether of simpler type. They are, in fact, more closely related to Fishes, with which they are sometimes associated to form a larger group, the ICHTHYOPSIDA, or Fish-like Animals (Gk. *ichthus*, fish; *opsis*, appearance), as has already been stated. A typical species will here be briefly described, and a comparison with what has been said about the Sand Lizard (p. 191) will illustrate the points of agreement as well as of difference between Amphibians and Reptiles.

The Spotted Salamander (*Salamandra maculosa*) (fig. 152) is a European animal from 6 to 9 inches long which has long attracted attention, mainly perhaps on account of its supposed power of withstanding fire. The flattened rounded head is not separated by any appreciable neck from the somewhat clumsy trunk, which passes gradually back into a long thick tail. The four sprawling limbs are directed a good deal outwards, and scarcely lift the body from the ground: the fore-limb possesses four digits, the hind-limb five. The mouth is a wide slit, and the two small valvular nostrils are placed near the tip of the blunt snout. Large eyes, provided with upper and lower eyelids, are present, but no trace of auditory organs can be seen externally. There is a longitudinal slit, the opening of the cloaca, on the under side of the body near the root of the tail.

The animal is rendered very conspicuous by its colouring, which consists of a ground of black, upon which are arranged broad patches of orange-yellow. The skin differs markedly from that of a reptile, for it is soft, moist, and smooth, being entirely devoid of scales, plates, or claws. Its damp feel is due to the secretion of very numerous skin-glands, some of which secrete

a poisonous fluid. Of these the most conspicuous are grouped so as to form a swelling behind either eye.

The *internal skeleton* (fig. 149) is not so bony as in a reptile, consisting largely of tough membrane and gristle. The *skull*, like that of a mammal, has a pair of condyles at the back for joining on to the backbone. There is no quadrate bone, but the lower jaw is hinged on to a cartilaginous projection of the skull which represents it. The "hyoid apparatus" (see p. 29) in the floor of the mouth consists of a small unpaired cartilage in the middle line and other pieces of cartilage at the sides, of which three pairs are the most conspicuous. These, as we shall see later, are vestiges of structures which were once more important.

The *backbone* consists of a considerable number of fairly bony vertebræ, the centra of which are for the most part convex in front and concave behind, just the reverse of what is true for most reptiles. This is only characteristic for some of the Amphibia, however. The following regions can be distinguished: neck, trunk, sacral, and tail. Only the first vertebra, the ring-shaped *atlas*, can be considered as definitely belonging to the neck region. It, and the hinder vertebræ of the tail, bear no *ribs*, which are present, however, as short slender bones in all the others. There is a single sacral vertebra united to the pelvis by means of its ribs, and forming a division between the trunk vertebræ in front and the caudal vertebræ behind. A *sternum* is present in the form of a small plate of cartilage on the under side, but this, from the way in which it is developed, appears to be equivalent to two small abdominal ribs fused together, and is not, therefore, of the same nature as the part so called in the higher vertebrates.

The *limbs* are supported by an internal skeleton, which corresponds very closely with the patterns described on pp. 196–198. Indeed it ought to be stated that these patterns are very largely founded on what is seen in the Amphibia, these being the simplest backboned animals possessing limbs suited for progression on the ground. Two deviations from the pattern may, however, be noted, one being that in the fore-limb the little finger is entirely absent, while the other is that in the pelvic girdle there is no clear boundary between pubis and ischium, the two being represented by a plate of cartilage with the hinder part of which a bony plate is connected.

There are not many points which need detain us in the structure of the *digestive organs* (fig. 150). A considerable number of small *teeth*, with forked crowns, are fused with the bones which form the margins of the jaws, and there are two longitudinal rows of similar teeth on the roof of the mouth. Gullet, stomach, small intestine, and large intestine are present, the last being very short and opening behind into a cloacal chamber. The Salamander is found in damp places, where it lurks in crevices, coming out in the evening or during rain to feed upon worms, snails, and slugs.

Very special interest attaches to the *circulatory organs* (fig. 150), especially as regards the structure of the heart and the arrangement of the large arteries. There is a certain agreement with the Sand Lizard (see p. 191) in so far that the great veins open into a thin-walled *venous sinus*, that pours the impure blood it receives from them into a *right auricle*, which is separated by a party-wall from a *left auricle* receiving pure blood from the lungs. Both auricles open into the single *ventricle*. But there is here not even an internally projecting ridge for partial division of the ventricle into right and left halves, and there is an additional region to the heart, the *arterial cone*, a tube which is in communication with the cavity of the ventricle on the right-hand side, and from which the great arteries take origin in the form of four pairs of arterial arches. It is now time to consider more fully the actual meaning of such arches, which have been seen to be present, though in a much less pronounced form, in Reptile, Bird, and Mammal (see p. 201).

A Salamander when starting an independent existence is unlike the adult in many important respects, and is therefore called a *larva*. In this particular case, though a pair of small lungs are present, they are, to begin with, of little or no use for breathing purposes. The efficient organs of respiration are three pairs of feathery gills growing from the sides of the throat, and containing a net-work of delicate blood-vessels. Floating freely in the surrounding water, these gills present a large surface through which the dissolved oxygen can diffuse into the blood and the waste carbon dioxide diffuse out of it. Close inspection reveals the presence of four small *gill-slits* on each side of the throat, by which the back part of the mouth-cavity communicates with the exterior, and each slit is in front of a corresponding

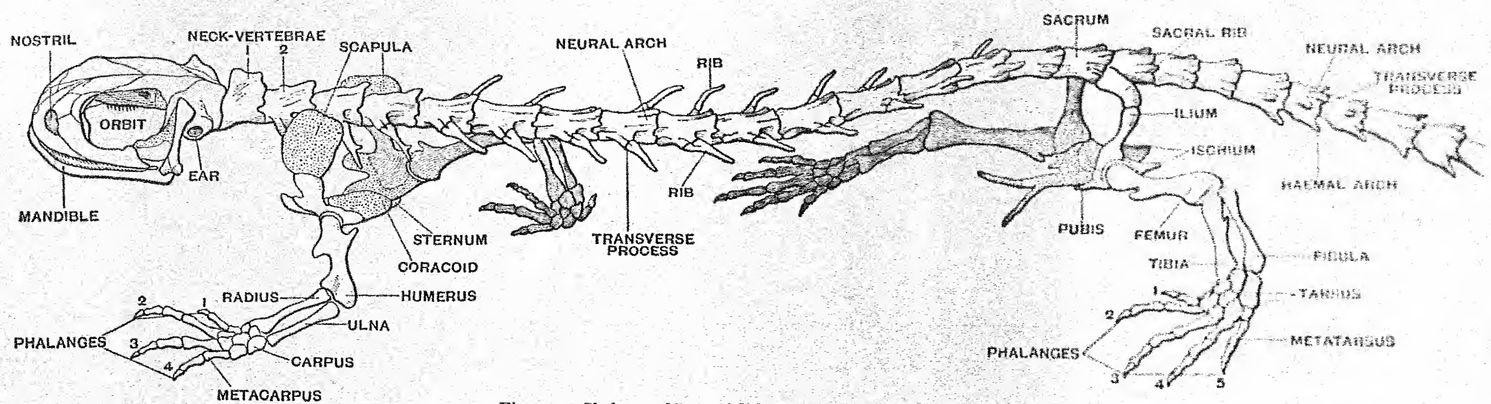


Fig. 149.—Skeleton of Spotted Salamander (*Salamandra maculosa*)

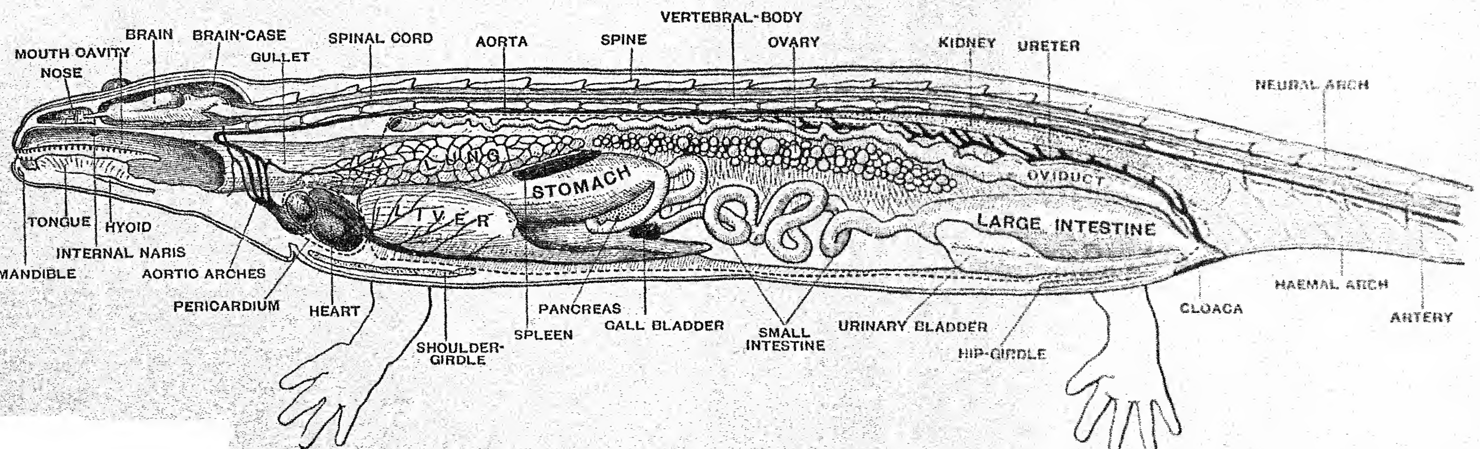


Fig. 150.—General Structure of Spotted Salamander (*Salamandra maculosa*)

bar-like thickening or *gill-arch.* These bars and slits are good examples of visceral arches and clefts, the presence of which at some period of life or other is one of the primary characteristics of a Vertebrate (see p. 62). The three gills on each side grow out from the tops of the three first gill-arches. The heart of the larva contains impure blood only, returned from all parts of the body, and its function is to pump this blood to the gills for purification through paired afferent branchial vessels which run within the gill-arches. The purified blood is collected up from the gills and distributed to the body by efferent branchial vessels which unite above to form a dorsal aorta. Each afferent vessel, with the corresponding efferent one, constitutes what may be called an *aortic arch.* As the larva gradually assumes the structure of the adult all the gill-slits close, the gills at the same time shrivelling up. Meanwhile the lungs have increased in size, and take on the work of purifying the blood, and the aquatic gill-bearing larva is thus converted into a terrestrial air-breathing Salamander. The heart now receives not only impure blood from the body, but also purified blood from the lungs, and it becomes necessary to solve the problem of how to keep these two sorts of blood separate by modifying an arrangement specially adapted for pumping impure blood to the gills. To use an illustration, it is as if a pumping apparatus made for distributing cold water were to be also connected with a warm-water supply, and one were then called upon to modify the apparatus so as to keep the two kinds of water as distinct as possible. The problem is only partially solved in the Salamander, for the separation of the two kinds of blood is incomplete, the result being that some of the blood distributed by the heart is impure, some pure, and the rest mixed. Just as if, in modifying the supposed pumping apparatus, we succeeded to a certain extent, part of the warm and cold supplies mixing, however, to give tepid water. In such an event the pump would distribute three kinds of water as regards temperature, *i.e.* cold, warm, and tepid, these corresponding to the impure, pure, and mixed blood of the Salamander.

It would take too much space to fully describe how the circulatory organs of the Salamander are modified during the change from larva to adult, but some of the leading features may be noted. To begin with, the originally single auricle is

divided into two, a right half to receive the impure blood and a left to receive the pure, and although these two halves possess a common opening into the undivided ventricle, yet the prolongation of the party-wall between them into that opening prevents the blood from mixing there. Arrived in the cavity of the ventricle, which is transversely elongated, mixture does not take place so much as would be anticipated, for there is a system of ingrowths from the ventricular wall which largely prevents this, so that the blood passed into the right side of the ventricle remains impure and that on the left pure, while between the two comes a zone of mixed blood. The arterial cone to which blood from the ventricle passes on is placed on the right, and when the ventricle contracts it receives first *impure*, then *mixed*, and lastly *pure* blood, as the result of the arrangement just described. Next, as to the way in which the four pairs of aortic arches coming off from the arterial cone are modified for their new purpose. The first pair, which supplied the first gills, are converted into *carotid arches* running to the head; the second and third pairs, which supplied the corresponding gills, unite to form the *dorsal aorta*, and supply most of the body except the head; while the fourth aortic arches, branches of which have all along supplied the lungs, continue to do so, having, however, enlarged. And it is interesting to notice that the parts of the fourth arches which connect them with those in front become converted into fibrous cords through which blood is not able to pass. It is clear, therefore, that the blood received by the cone must go either to the head, general body, or to the lungs, its course for any given moment being in the direction of least resistance. Now, when the ventricle begins to contract, forcing out blood which is quite impure, the easiest course is to the lungs, and this impure blood takes that course and flows to the lungs for purification. As that is being accomplished mixed blood begins to flow into the cone, and by this time the easiest course is through the second and third arches to the general body, since the fourth arches have just been filled and can take no more. Meanwhile the ventricle has begun to squeeze out its remaining blood, which is pure, and the easiest course this can take is through the first arches to the head. Containing as it does the brain and highest sense organs, it is important for the head to receive, as in fact it does, the purest blood-supply.

Two things will now have become apparent if the foregoing description has been carefully followed: (1) That the aortic arches found in higher Vertebrates, which always breathe by lungs, point to descent from ancestors which were aquatic and breathed by means of gills growing from gill-arches between which there were gill-slits; (2) the Amphibians and Reptiles are, so to speak, still grappling with the problem of adapting a circulatory system originally suited for pumping impure blood to gills, to the new conditions brought about by the adoption of a terrestrial life. Even in crocodiles, which by development of two ventricles have succeeded in preventing the two sorts of blood from mixing in the heart itself, have not been successful in preventing them from mixing outside the heart (see p. 208). These facts become clearer still when the development of the higher Vertebrates is studied, and in, say, an embryo chick (fig. 151) gill-arches and clefts are clearly to be seen with their aortic arches, although no true traces of actual gills have been discovered. It may also be pointed out that gill-arches are supported by parts of the internal skeleton in the form of jointed rods which unite with unpaired pieces in the floor of the throat, and the "hyoid apparatus", which has been described in various animals, is largely made up of bits of this gill-arch skeleton, now turned to further uses. The cartilages which support the larynx or voice-box of terrestrial Vertebrates are also derived from this source, in part at least. These are admirable examples of "change of function" (p. 13).

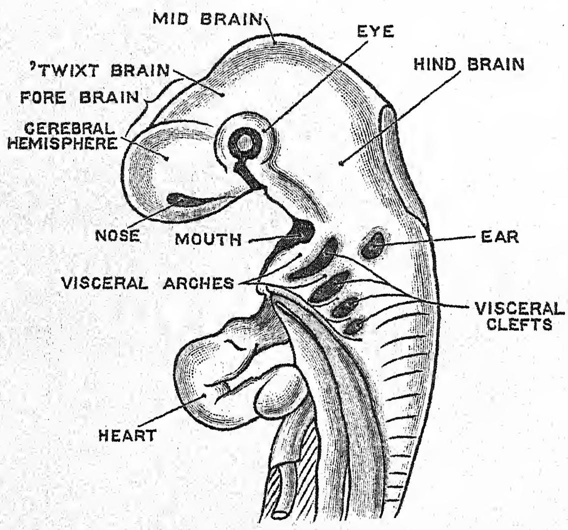


Fig. 151.—Front part of Chick Embryo

The *breathing-organs* (fig. 150) of the adult Salamander have already been spoken of in the foregoing, but it may be added that the lungs and air-passages agree fairly well with what has

been described for the Sand Lizard (see p. 191). The provision for renewal of air in the lungs is, however, different, for there is here no means of altering the capacity of the chest by movements of ribs and sternum, air being in this case renewed in the lungs by the upward and downward movement of the floor of the mouth-cavity. During this process the mouth is kept shut, air passing from and to the exterior through the nose, which opens externally by valvular nostrils and internally by small apertures on the roof of the mouth.

The Salamander, too, is not altogether dependent on the lungs for the purification of its blood, as the moist skin also serves as an accessory breathing-organ, the blood which it purifies entering the great veins which pour impure blood into the sinus venosus. This blood is therefore less impure than would otherwise be the case.

The *brain* (fig. 150) is much like that of the Sand Lizard, but is of lower type, it being especially noticeable that both cerebral hemispheres and cerebellum are smaller in proportion. As regards the chief *sense organs*, the eye is not provided with a third eyelid, and its crystalline lens is spheroidal instead of being biconvex as in animals better adapted for a terrestrial life. The ear on each side consists essentially of a membranous labyrinth not unlike that found in a Lizard (see p. 203). There are, however, no special arrangements, for conducting sound-waves. This, however, is not a feature which characterizes all Amphibia; the frog, for example, having a tympanic cavity and tympanic membrane, and a small rod, the columella or ear-bone, running from that membrane to the part of the skull in which the membranous labyrinth is lodged.

The Amphibia now living are divided into three orders:— 1. Urodela, or Tailed Amphibia; 2. Anura, or Tailless Amphibia; and 3. Gymnophiona, or Limbless Amphibia.

Order 1.—Tailed Amphibians (Urodela)

Salamanders, Newts, and allied forms are here included (fig. 152). The Spotted Salamander (*Salamandra maculosa*), just described, is a good example of the Urodela. Its relative, the Black Salamander (*S. atra*), is a smaller Alpine form, and other allied species inhabit the Peninsula and the Caucasus.

Newts or *Efts* differ from Salamanders proper in the possession of a tail flattened from side to side and used as a swimming organ. Running round the margin of the tail is a fin-like expansion, which, however, is not supported by hard parts as in a fish. Three kinds are native to Britain, and constitute our only representatives of the tailed Amphibia. Of these the

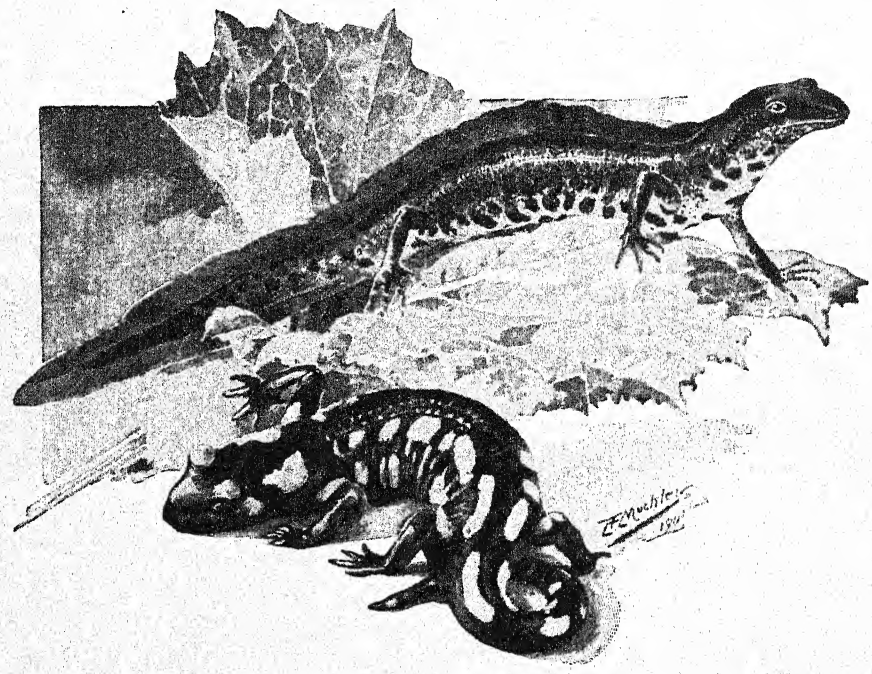


Fig. 152.—Tailed Amphibia.—Spotted Salamander (*Salamandra maculosa*), below. Crested Newt (*Triton cristatus*), above.

commonest is the Small Newt (*Triton tæniatus*), which is only a little more than 3 inches long. The upper surface and sides are olive-coloured, with dark spots and streaks, while the paler under side is marked by a longitudinal orange-coloured band. The male has a fin-like crest running down the middle line on the upper side of the trunk, and continued into a similar fold which margins the tail: the colouring and marking are not quite the same as in the female. Another British species, the Crested Newt (*Triton cristatus*), may be more than 5 inches long, and the crest on the back of the male is much better developed. The only other species found in this country, and that less frequently, is the Webbed Newt (*Molge palmata*), which is not more than 3 inches long. There are no spots on the under surface, and the hind-feet of the male are webbed.

The largest living Amphibian is the Giant Salamander (*Megalobatrachus maximus*) from Japan and China, which is commonly 3 feet long, and is said to attain a still greater size.

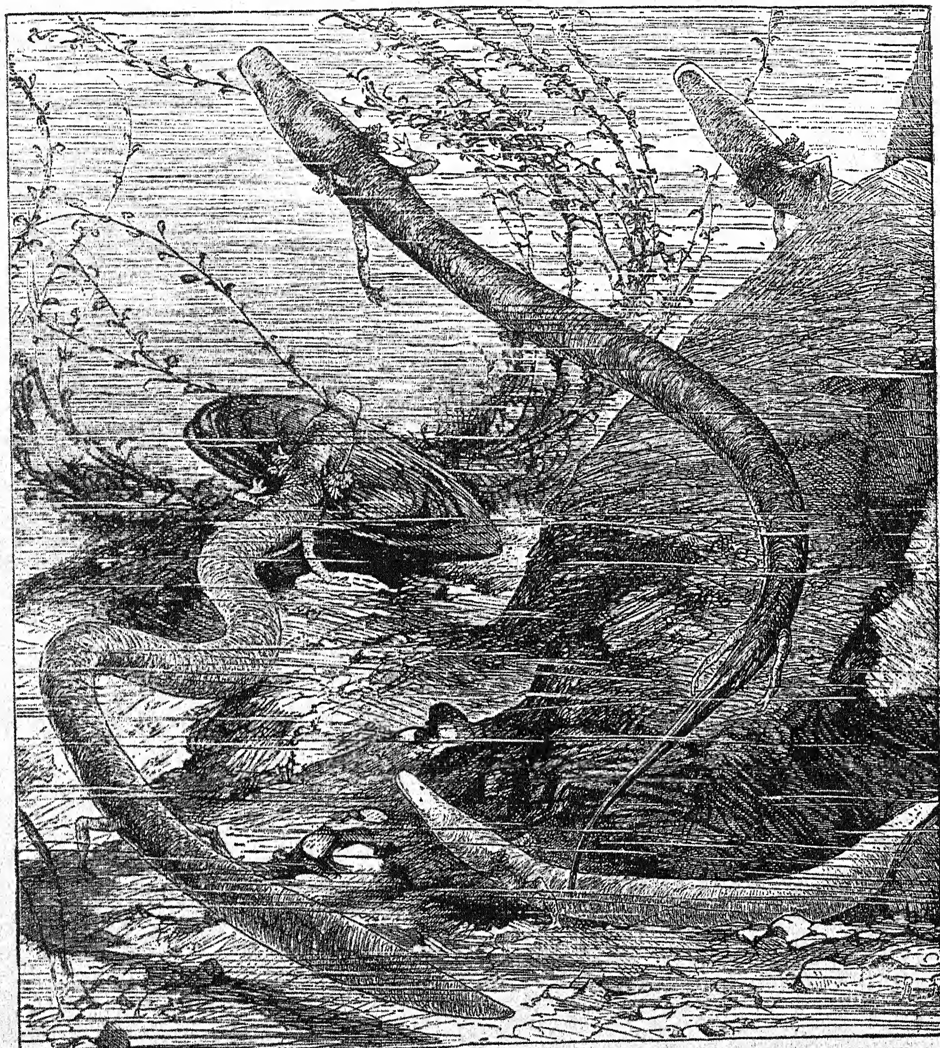


Fig. 153.—The Olm (*Proteus anguineus*)

It is a clumsy-looking creature, with a huge flattened head, broad rudder-like tail, and short, unfinished-looking limbs. The body is covered with a dark leathery skin, raised into numerous warts, and exhibiting a thick wavy fold on each side. This creature is a representative of a group of forms known as "Fish Newts", in which the trunk is long and the limbs weak, while other

primitive characters are present, such as biconcave centra to the vertebræ, eyelids represented by a circular fold, and (except in the Giant Salamander itself) persistent remains of a gill-breathing condition, seen, it may be, in the actual retention of gills along with the lungs, or of a pair of gill-slits in the throat.

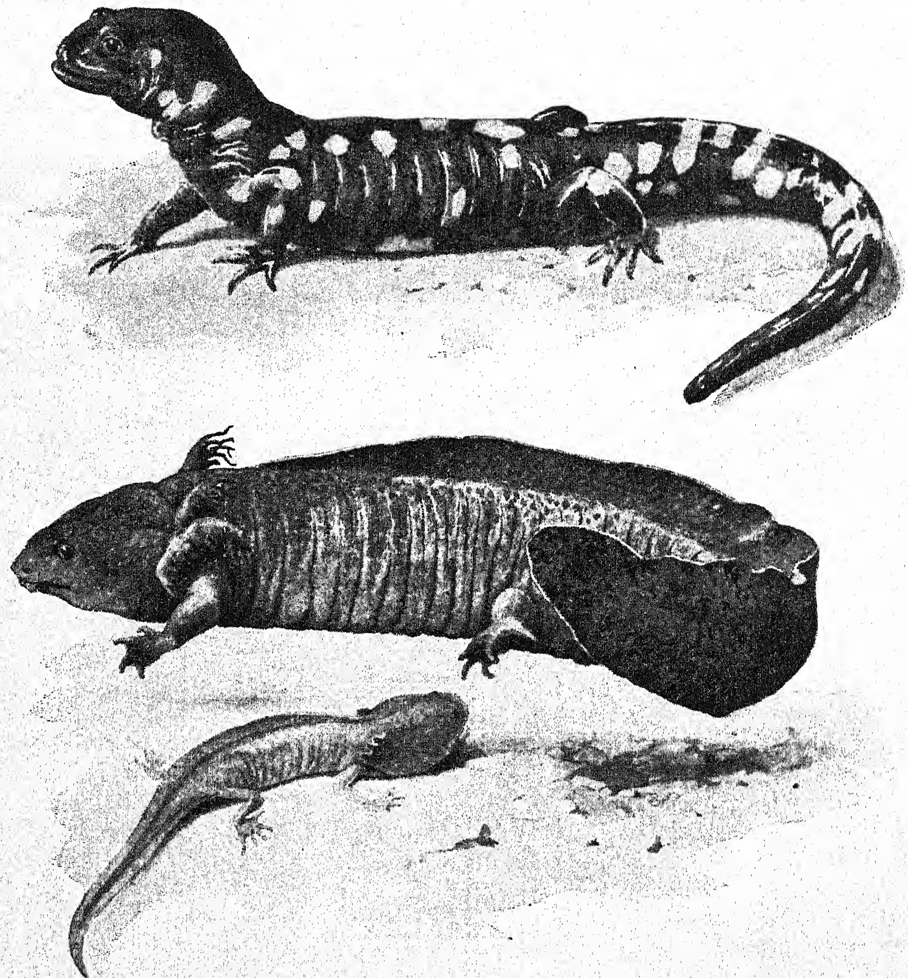


Fig. 154.—The Axolotl
Adult or salamander stage (*Amblystoma tigrinum*), above; larval or axolotl stage (*Siredon Mexicanus*), below.

The Hell-Bender, or Salamander of the Mississippi (*Cryptobranchus lateralis*), has a pair of gill-clefts, or sometimes one on the left side only. The Three-toed Salamander (*Amphiuma means*), from the same river, is eel-like in shape, with very small weak limbs, terminating in three or it may be only two digits. A pair of gill-slits are present.

The flesh-coloured Olm (*Proteus anguineus*) (fig. 153) is a remarkable eel-like form, about 10 inches long, which inhabits the underground lakes and streams of certain caves in Dalmatia, Carniola, and Carinthia. Both fore- and hind-limbs are very small, and furnished respectively with three and two digits. Coral-coloured external gills are present as well as two pairs of gill-slits. The eyes are small and concealed beneath the skin. Much longer (28 inches) than the Olm is the Siren (*Siren lacertina*) of the south-east part of the United States. The dark-coloured body is extremely eel-like and the hind-limbs are entirely absent, while the four-toed fore-limbs are very small. External gills and three pairs of gill-slits are present.

One of the most interesting Urodeles is the Mexican Axolotl (fig. 154), which in what must be called the adult state is a thorough-going Salamander, known as *Amblystoma tigrinum*, and in the United States, to which the range of the animal extends, this adult condition is reached. In the lake surrounding the city of Mexico, however, this is not the case, and the Axolotl permanently remains in the larval state, resembling an enormous newt tadpole. Gill-slits and external gills are present, and eggs are laid just as by adults. We have here the astonishing phenomenon of an animal which, so to speak, is dropping the adult stage out of its life-history, the conditions being unfavourable for its development. We only know this by accident, and the precocious tadpoles were, when first described, thought to be adult, receiving the name of *Siredon Mexicanus*. There are doubtless other still undetected cases of this remarkable phenomenon in the animal kingdom.

Order 2.—Tailless Amphibians (Anura)

While the Tailed Amphibia are confined to the Northern Hemisphere, the Frogs and Toads, which constitute the group of Tailless Amphibia, are cosmopolitan. The Grass Frog (*Rana temporaria*), which is one of the most familiar British Vertebrates, is a good type of one of the most widely-distributed families of the order, and a brief description of its more obvious external characters (fig. 155) will illustrate the differences which distinguish animals of the sort from Salamanders and their allies.

The flattened triangular head, with rounded snout, passes

into a short plump body without any intervening neck-region. In the adult animal there is absolutely no trace of a tail, though this is well-developed in the larval form or tadpole, a fact which no doubt points to the descent of Frogs from tailed ancestors. The limbs are much better developed than in the Salamander, but the hind-limbs, which serve both as leaping and swimming

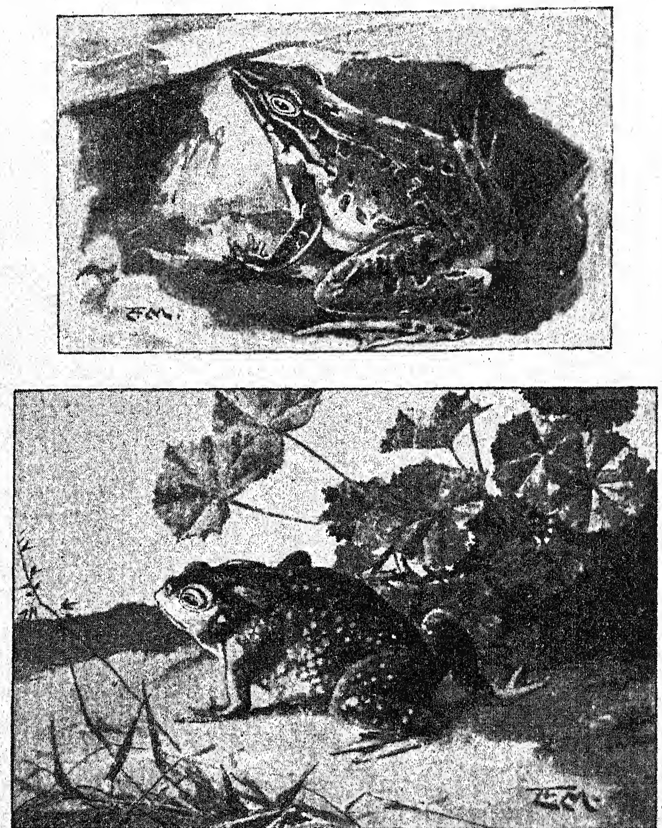


Fig. 155.—Tailless Amphibia
Grass Frog (*Rana temporaria*), above; Common Toad (*Bufo vulgaris*), below.

organs, are out of all proportion large as compared with the fore-limbs. Four digits only are externally visible in the latter, there being no apparent trace of a thumb, but the hind-limb possesses five well-developed toes, between which a delicate web extends. A very curious feature is the presence of a little horny spur, the *calcar*, on the inner side of the foot, and examination of the skeleton shows that this is really an extra digit, though in a much-reduced condition.

Nostrils and eyes are present closely resembling those of a Salamander, but behind either eye may be seen a well-marked rounded area corresponding to the tympanic membrane covered over by skin. A small rounded cloacal aperture is present at the hinder end of the trunk. The skin is soft and moist, as in Amphibians generally, and is entirely devoid of hard parts, with the trifling exception of the horny spur on the foot. The upper surface is mottled and the under surface pale, and, as in the Chameleons, though not quite to the same extent, the animal has the power to adjust its colour so as to match the surroundings for the time being. A frog which has been kept for some time in a dark place becomes almost black in colour, but if the same animal is transferred to grass it will gradually assume a greenish tint.

Endoskeleton (fig. 156). The peculiarities of the *skull* cannot be entered into here, but as regards the *backbone*, it may be said that the number of vertebræ is reduced to ten, their centra, too, being concave in front and convex behind, as in Reptiles. The first vertebra is a ring-like *atlas*, and the last fulfils the function of a *sacrum*, being connected with the hip-girdles supporting the hind-limbs. The hinder end of the backbone is completed by a bony rod, the *urostyle*. No separate *ribs* can be distinguished, but there is reason to believe that the prominent transverse processes which project from the sides of the vertebræ are partly equivalent to these. It is quite a common thing for ribs to fuse with vertebræ, at least in certain regions, *e.g.* in the human skeleton short neck-ribs have undoubtedly been soldered, so to speak, with the vertebræ which support the neck.

The *sternum* is much better developed here than in the Salamander, and is closely connected with the *shoulder-girdles*. These present the typical regions, but it may be noted that the precoracoid bar is covered over by a collar-bone or clavicle. The skeleton of the rest of the *fore-limb* corresponds fairly well with the pattern limb (see pp. 196–198), and a vestige of the thumb can be made out. The forearm, however, presents a very interesting case of fusion, for its two typical bones, the radius and ulna, are here closely united together. In the *hind-limb* a number of instructive variations on the pattern form are to be seen. The *hip-girdles* are quite unlike the corresponding parts in a

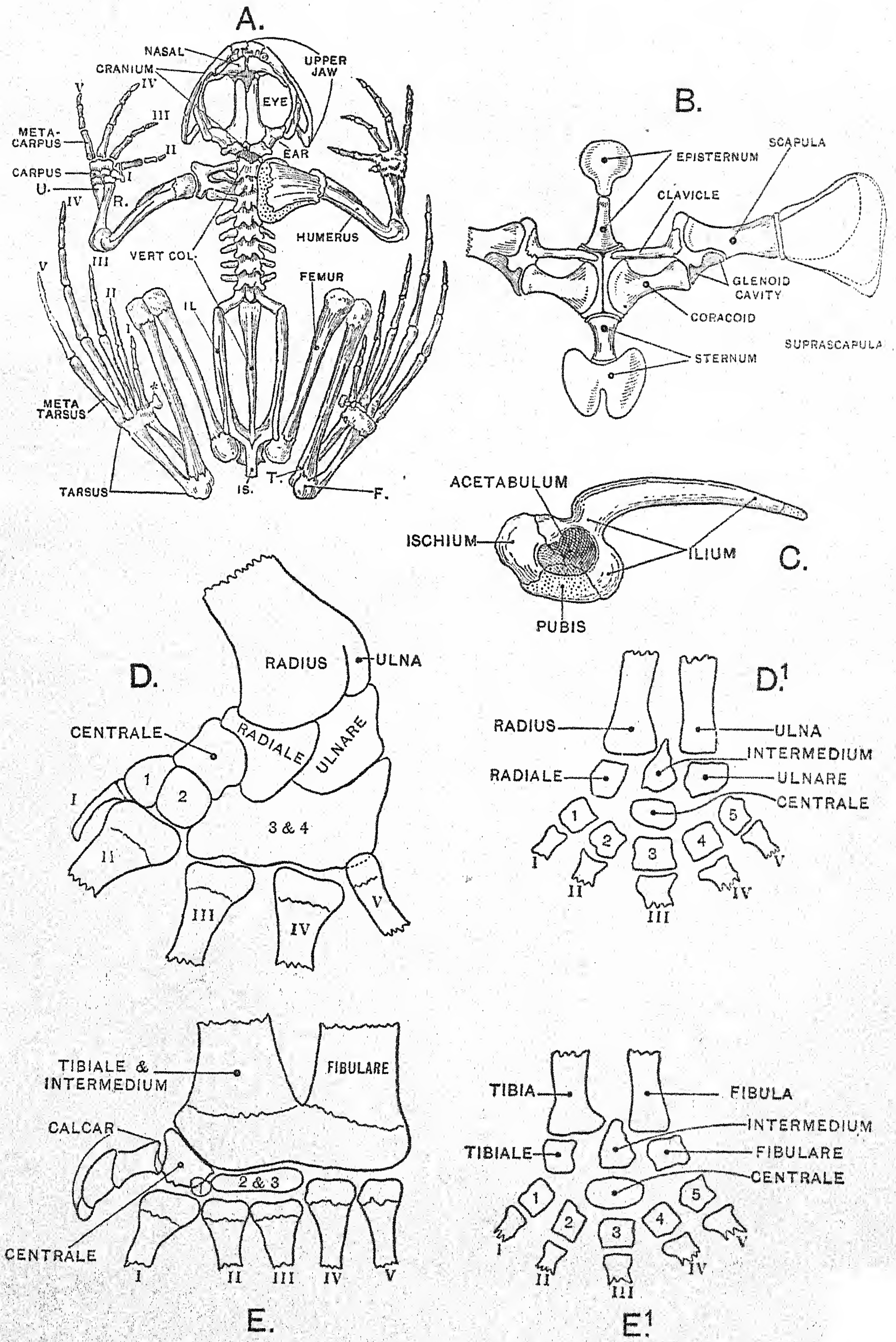


Fig. 156.—Skeleton of Frog

A, Skeleton seen from above (R, radius; U, ulna; IL., ilium; IS, ischium; T, tibia; F, fibula; *, calcar). B, Sternum and shoulder-girdles. C, Right hip girdle, from side. D, Wrist. D′, Pattern wrist. E, Ankle. E′, Pattern ankle.

Salamander. They are very intimately united into a forked bone, of which the forwardly-directed prongs are the ilia. The bones of the free limb are longer in proportion than in the fore-limb, and the bones of the lower leg, tibia and fibula, are fused together just like the radius and ulna in the fore-limb. Great specialization has taken place in the *tarsus*, for while that part of it next the fused tibia and fibula is represented by two elongated bones (= tibiale and fibulare) the rest has dwindled

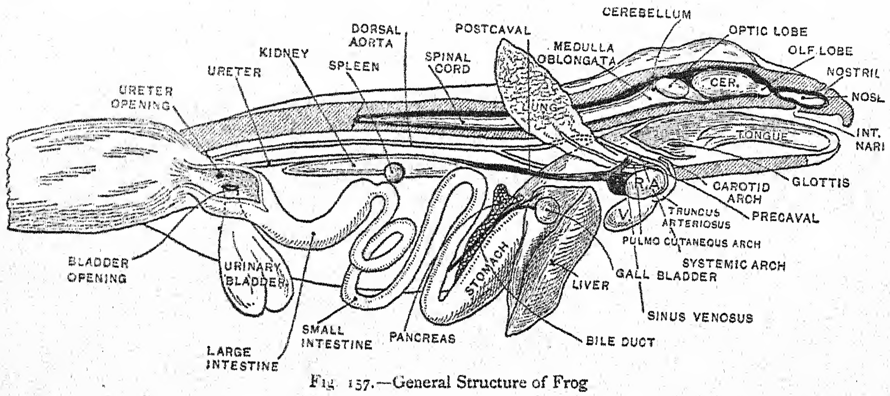


Fig. 157.—General Structure of Frog

away to insignificant vestiges. All this is to fit the limb for its use as a leaping organ, and changes of similar kind are seen in certain Mammals which use the hind-limbs in the same way. It is another illustration of the close connection which exists between form and function, though much space would be required to work it out in detail, even had we all the necessary data, which does not appear to be the case.

Broadly speaking, the *digestive organs* (fig. 157) agree with those of the Salamander except as regards the teeth and tongue. The *teeth* are entirely absent from the lower jaw, though they fringe the upper jaw, and occur in two small groups on the roof of the mouth. The long forked *tongue* has the remarkable peculiarity of being attached to the front of the mouth-floor, with its tip pointing backwards when not in use. It is an insect-catching organ of no mean order of perfection, which can be whipped out of the mouth with great rapidity and as rapidly drawn back, generally carrying with it the desired booty.

The *circulatory organs* are built on the same type as those of the Salamander (see p. 240), and keep the impure and pure blood separate to the same extent, supplying the former to lungs

and skin for purification and the latter to the head, while the greater part of the body has to put up with mixed blood. There are, however, numerous minor differences, one of the most striking being the presence of three pairs of aortic arches as against four, those corresponding to the third pair in the Salamander having disappeared.

The *lungs* are similar in nature to those in the Salamander (see p. 244), being a pair of bags, the linings of which are raised into a honeycombing of ridges. The supply of air of the lungs is renewed in the same way, by a pumping action in the mouth-cavity, the floor of which is alternately raised and lowered.

The only points in the *nervous system* and *sense organs* which need be noticed are the extreme shortness of the spinal cord and the presence of a sound-conducting middle ear not unlike that present in the Sand Lizard (see p. 192).

The *life-history* of the Frog is extremely interesting. From the eggs are hatched fish-like limbless tadpoles, in which the breathing organs are at first *external gills*, like those of the larval Salamander (see p. 240). After a time, however, these begin to shrivel and are replaced by the so-called *internal gills*, consisting of folds on the walls of the four pairs of gill-clefts, quite unlike anything found in the Tailed Amphibia but closely resembling the gills of some fishes. As these gills develop, a fold of skin grows backwards over the gill-slits and unites to the body behind them, leaving only a small round hole on the left side through which is expelled the water that has been taken in at the mouth and passed through the gill-slits. The adult form is reached by growth of limbs, accompanied by loss of tail and closure of the gill-slits, the lungs assuming their adult function. There is also a change in the nature of the food, for a tadpole is a vegetarian while the adult frog lives on insects and other small animals.

The Grass Frog has a wide distribution through Europe and non-tropical Asia, while the family (Ranidæ) to which it belongs is represented in all parts of the world except New Zealand and Polynesia. The well-known Edible Frog of the Continent (*Rana esculenta*) is common in the east of England, but has most likely been introduced. Much larger species of the same family are the Bull Frog (*Rana Catesbyana*), inhabiting the east of North America and attaining a length of over 7 inches,

while Guppy's Frog (*Rana Guppyi*) from the Solomon Islands is nearly a foot long.

The Common Toad (*Bufo vulgaris*) is a more sluggish animal than the Grass Frog, and better adapted to a terrestrial life (fig. 155). Its skin is dull and warty, and prominent neck-glands like those of the Salamander are present. Teeth are entirely absent. The range of this species is even wider than that of the Grass Frog, for it is found in North-west Africa as well as in Europe and Asia.

Another species of toad found in Britain, though less frequently than the ordinary kind, is the Natterjack (*Bufo calamitata*), readily distinguished by a yellow or whitish streak down the middle of the back. The family to which both these toads belong (Bufonidæ) is almost as widely distributed as the Ranidæ, but is absent from Madagascar and rare in the Australian region.

There are thirteen other families of the Tailless Amphibia besides those mentioned, but none of them are so widely distributed, and some have a very restricted range.

Order 3.—Limbless Amphibians (Gymnophiona)

The remarkable modifications which have taken place in the bodies of some Fish-Newts, such as the Siren (see p. 248), are carried a step further here, for the tropical worm-like creatures (fig. 158) which make up the order are entirely limbless, tailless, and modified in other ways for a burrowing life. The body of a Cæcilian is encircled by grooves, and in some species small bony plates are imbedded in the skin. The small mouth is provided with sharp backwardly-curved teeth suited for the capture of earth-worms, insects, and other small creatures. The

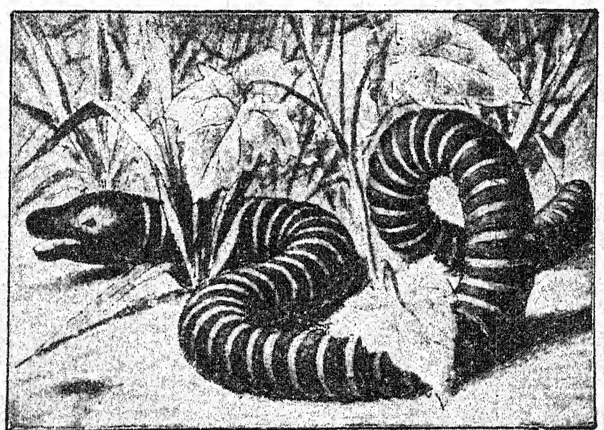


Fig. 158.—A Cæcilian (*Siphonops annulata*) from tropical America

vertebræ exhibit the primitive feature of biconcave centra, and small movable ribs are attached to them. There is no sternum, and even the limb-girdles are absent. As in Snakes, some of the internal organs are modified to suit the narrow shape of the body, and it may be mentioned in particular that the right lung is much larger than the left. In regard to the sense organs, it may be noticed that the small eyes are hidden under the skin and the sound-conducting middle ear is absent. The development of an East Indian form (*Epicrium glutinosum*) has been studied, and presents some curious points. When the embryo is hatched it possesses three pair of external gills, a pair of gill-slits, a short tail, and traces of hind-limbs. Immediately hatching takes place, however, these gills are lost; but in spite of this the larva takes to the water and lives there for some time.